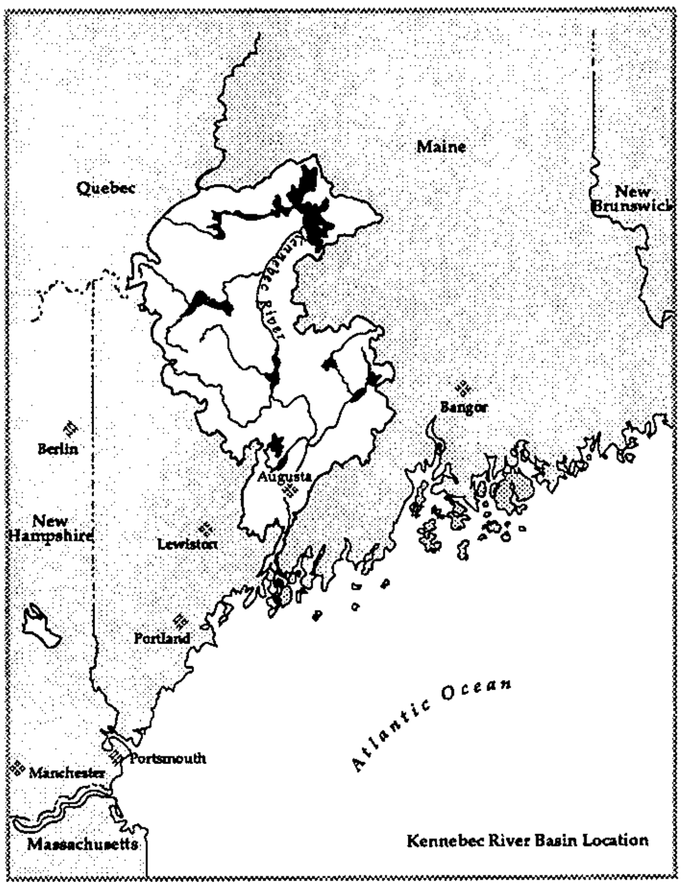
WATER RESOURCES STUDY

Kennebec River Basin
Maine

Volume II
Supporting Documentation

KENNEBEC RIVER BASIN STUDY



February 1990

US Army Corps
of Engineers
New England Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
February 1990

3. REPORT TYPE AND DATES COVERED
Water Resources Study

4. TITLE AND SUBTITLE
Water Resources Study, Kennebec River Basin, Maine
Vol. 2, Supporting Documentation

5. FUNDING NUMBERS

6. AUTHOR(S)
U.S. Army Corps of Engineers
New England Division

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers, New England Division
424 Trapelo Road
Waltham, Massachusetts 02254-9149

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Hydrologic Engineering Section
Water Control Branch
424 Trapelo Road
Waltham, Massachusetts 02254-9149

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Kennebec River Basin Study

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release
Distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This study, volume 2, contains the documentation supporting the conclusions and recommendations of volume 1.

14. SUBJECT TERMS
hydrology; hydraulics; environmental; economics

15. NUMBER OF PAGES
100

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

WATER RESOURCES STUDY
KENNEBEC RIVER BASIN
MAINE

SUPPORTING DOCUMENTATION

February 1990

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

TABLE OF CONTENTS

SECTION I

HYDROLOGIC ANALYSIS

KENNEBEC RIVER, MAINE
HYDROLOGIC RECONNAISSANCE
FOR
FLOOD CONTROL

BY

HYDROLOGIC ENGINEERING SECTION
WATER CONTROL BRANCH
ENGINEERING DIVISION

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

DECEMBER 1988

KENNEBEC RIVER, MAINE
HYDROLOGIC RECONNAISSANCE
FOR
FLOOD CONTROL

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

KENNEBEC RIVER, MAINE
HYDROLOGIC RECONNAISSANCE
FOR
FLOOD CONTROL

1. PURPOSE AND SCOPE

This reconnaissance report presents hydrologic information and analysis relative to flood problems in the Kennebec River Basin in Maine. The study was performed under the authority contained in the Resolution of Senate Committee on the Environment and Public Works, adopted 5 May 1987. The March/April 1987 flood caused extensive damage throughout the watershed, resulting in the initiation of this investigation.

2. REFERENCES

a. New England-New York Inter-Agency Committee (NENYIAC) Report, Chapter VI, Kennebec River Basin, March 1955.

b. Hydrology of Floods, Kennebec River, Maine, Part I, Hydrologic Engineering Section, NED, September 1985.

c. Hydrology of Floods, Kennebec River, Maine, Part II, Hydrologic Engineering Section, NED, May 1988.

d. Flood of April 1987, in Maine, Massachusetts, and New Hampshire, U.S. Geological Survey, Open-File Report 87-460, 1987.

e. The Floods of March 1936, Part I, New England Rivers, U.S. Geological Survey Water Supply Paper 798, 1937.

f. Federal Energy Regulatory Commission, "Water Resources Appraisal for Hydroelectric Licensing, Kennebec River Basin," 1980.

g. Flood Insurance Study, City of Gardner, Maine, FEMA, November 1979.

h. Flood Insurance Study, City of August, Maine, FEMA, October 1980.

i. Flood Insurance Study, City of Waterville, Maine, FEMA, February 1988.

j. Flood Insurance Study, Town of Fairfield, Maine, FEMA, February 1988.

k. Flood Insurance Study, Town of Norridgewock, Maine, FEMA, June 1988.

3. BACKGROUND

The Kennebec River Basin has experienced numerous recent floods, including the disastrous March/April 1987 event. The Corps of Engineers has studied flooding in the Kennebec in the past. The two more recent studies: Hydrology of Floods, Parts I and II, along with the NENYIAC Report, and the data contained in the USGS Open File Report 87-460 and Water Supply Paper 798, were used to facilitate the current investigation. The Part I report presents a review and analysis of the hydrology of floods on the Kennebec River, including sections on basin description, climatology, flood history, and analysis of recent floods. The Part II report presents the results of exploratory system simulation studies in search of reservoir regulation guidance that might maximize the incidental flood control effectiveness of upper basin reservoirs while not impacting their design purpose, i.e., hydropower storage. Also presented was information on relative flood control effectiveness of potential new reservoir storages within the watershed, potential for added surcharge storage at existing reservoirs, and a summary hydrologic analysis of the March/April 1987 flood.

4. BASIN DESCRIPTION

a. General. The Kennebec River Basin, located in west-central Maine, has a total drainage area of approximately 5,900 square miles, constituting almost one-fifth the total area of the State of Maine. The Androscoggin River Basin lies to the west, the Penobscot River Basin to the north and east; and a section of the Maine coastal area to the south. The northwesterly limit of the basin forms a part of the international boundary between the United States and Canada. The basin has a length in the north-south direction of about 150 miles and a width of about 70 miles. The upper two-thirds of the basin, generally above Waterville, is hilly and mountainous, being part of the Appalachian Mountain Range. The lower one-third of the basin, including the Sebasticook River and Cobbosseecontee Stream tributary areas, has a more gentle topography representative of the coastal area. A map of the Kennebec Basin is shown on plate 1.

b. Kennebec River. The Kennebec River originates at the outlet of Moosehead Lake and flows southerly 145 miles to the head of Merrrymeeting Bay at Abagadassett Point, about seven miles above Bath. From Merrymeeting Bay the Kennebec waters continue south, through the Maine coastal area, another 120 miles to the Atlantic Ocean at Hunniwell Point. The main river is tidal as far as Augusta, 25 miles above Abagadassett Point. Between its origin and mean tide at Augusta, the river falls about 1,026 feet in a distance of 120 miles, an average gradient of 8.5 feet per mile. One "S" curve in the river, between Madison and Skowhegan, forms the only large digression in the river's southward course.

c. Tributaries. The principal headwater tributary is Moose River which drains 735 square miles of mountainous watershed area easterly to Moosehead Lake. The tributary area of the Moose River represents about 58 percent of the total Moosehead Lake watershed (1,268 square miles). The Moosehead Lake watershed, in turn, represents about one-fifth (20 percent) of the total Kennebec Basin area. Principal downstream tributaries (400 or more square miles) are the Dead, Carrabassett, Sandy, and Sebasticook Rivers. Individual drainage areas are listed in table 1. The combined drainage area of the four principal downstream tributaries is about 2,800 square miles, representing 47 percent of the total basin area and about 60 percent of the area below Moosehead Lake. Flagstaff Reservoir, another large regulated lake, is located in the Dead River tributary watershed. The Carrabassett and Sandy Rivers are hydrologically flashy, draining unregulated mountainous terrain, whereas, the Sebasticook River drains flatter more hydrologically sluggish terrain.

TABLE 1

KENNEBEC RIVER
PRINCIPAL TRIBUTARIES

Tributary	Drainage Area (sq. miles)	Length (miles)	Fall (ft)
Moose River	722	76	750
Dead River	867	23	570
Carrabassett River	401	35	636
Sandy River	596	69	1544
Sebasticook River	946	48	270

d. Dams and Reservoirs. There are 17 hydroelectric dams in the Kennebec River Basin with ten located on the main stem Kennebec and having 95 percent of total generating capacity in the basin. Dams on the main stem harness approximately 50 percent of the total fall of the river (reference f). All hydropower dams are run-of-river except Harris (Indian Pond) and Wyman which have storage capacity only for daily or weekly load fitting operations.

There is a total of about 1,300,000 acre-feet of reservoir storage in the Kennebec Basin, used for hydropower regulation, with about 86 percent of that storage located in the upper 46 percent of the watershed, upstream of Bingham, Maine. The other 14 percent is generally distributed between the Sebasticook, Messalonskee, and Cobbosseecontee tributary watersheds in the lower part of the basin below Waterville. Available reservoir storage in the upper basin has a marked effect on upper basin floodflow contributions to the Kennebec River. Principal storage reservoirs in the basin above Bingham are listed in table 2. There are 1,132,000 acre-feet of storage in the upper basin and 1,016,500 acre-feet, or 90 percent at the three lakes: Brassua, Moosehead and Flagstaff.

TABLE 2

AVAILABLE RESERVOIR STORAGE
KENNEBEC RIVER BASIN ABOVE BINGHAM, MAINE

Project	Drainage Area (sq. mi.)	Full Pool Surface Area (acres)	Drawdown (feet)	Storage (ac-ft)	Percent
Brassua Lake	710	8,979	30	196,500	17
First Roach Pond	63	3,270	7	21,500	2
Moosehead Lake	1,268	74,000	7.5	544,000	48
Indian Pond (Harris)	1,355	3,747	5	19,000	2
Moxie Pond	80	1,747	8	14,000	2
Flagstaff Lake	520	17,950	35	276,000	24
Wyman Lake	2,595	3,145	20	60,300	5
				1,132,000	100

5. FLOOD HISTORY

There are historical references to floods on the Kennebec River dating back to January 1770 but there is little information on the relative magnitude of floods prior to 1892. It was in 1892 that the Hollingsworth and Whitney Company began to maintain records of flows in the river at their dam in Waterville. Comparative peak flow data for nine flood events at selected locations in the basin since 1892 are listed in table 3. There are some inconsistencies in peak flow estimates for historic floods and many of the flood events included ice jams. The formation and breakup of ice jams could affect resulting local peak discharges and, most particularly, flood levels. The floodflow history would indicate that the December 1901 event approximated the March 1936 flood at Waterville. However, it is known that flood levels on the lower main stem of the Kennebec were affected in 1936 by ice jams. Prior to the March/April 1987 event, the March 1936 event was the greatest known historic flood on the lower main stem Kennebec.

The most recent Kennebec flood was the result of high volume rainfall and accompanying snowmelt occurring on the last day of March and the first day of April 1987. This rainfall followed several days of daytime temperatures in the sixties. The resulting runoff produced new floods of record in the Kennebec Basin generally from the mouth of the Carrabassett tributary downstream throughout the middle and lower basin. Peak flows on the lower main stem Kennebec and tributaries (Sandy, Carrabassett and Sebasticook Rivers) ranged from 20 to 30 percent greater than the previous record flood of March 1936.

Floods in the basin have occurred most frequently in the spring as a result of snowmelt alone or in combination with rainfall. However, two floods were experienced in December, both as a result of mostly intense rainfall. Also a more recent flood event, in May/June 1984, occurred as a result of intense rainfall. Though there was a great flood on the river in December 1901, hydrologic data for the event is sketchy and questionable due to difficulties in developing reliable rating curves. The major flood of 1936 was really the first event with reasonably sufficient flow data for analysis. Though the 1936 event was a major flood, Moosehead Lake storage controlled the flood runoff from its 1,268 square miles of watershed and outflow from the lake did not significantly contribute to downstream flood peaks. Similarly, in the lesser March 1953 flood, Flagstaff Lake, completed in 1950, in combination with Moosehead Lake, provided a high degree of control over floodflow contributions

TABLE 3

KENNEBEC RIVER BASIN
FLOOD HISTORY (1892 - DATE)

Flood	Peak Discharges						
	Kennebec at Forks (1) (DA = 1,590)	Kennebec at Bingham (1) (DA = 2,715)	Kennebec at Skowhegan (2) (DA = 3,894)	Kennebec at Waterville (3) (DA = 4,270)	Kennebec at North Sidney (DA = 5,478)	Sandy River Nr Mercer (1) (DA = 514)	Carrabassett River Nr North Anson (1) (DA = 353)
Mar 1896	-	-	-	113,000 cfs	-	-	-
Dec 1901	22,400	-	-	157,000	-	-	-
Apr-May 1923	17,700	-	-	135,000	-	-	-
Mar 1936	15,200	58,000	113,000(4)	154,000	-	38,600	38,000
Mar 1953	8,000	28,400	-	112,000	-	36,900	30,400
Dec 1973	24,900	50,300	110,000 (123,000)(5)	145,000(6)	-	25,600	20,000
Apr 1979	77,200	41,000	101,000	105,000(7)	111,000	24,900	22,400
Apr 1983	28,300	55,400	82,000	90,000(7)	107,000	-	13,700
May-Jun 1984	31,500	65,200	76,000	102,000(7)	113,000	-	13,000
Mar-Apr 1987	20,400	63,400	-	190,000(7)	220,000	46,000	41,000

(1) USGS Gaging Station.
(2) Daily flow data by Kennebec Water Power Company and Central Maine Power Company.
(3) Data by Hollingworth and Whitney Company.
(4) From Corps file notes.
(5) Newspaper account of peak.
(6) From Regional Planning Committee Flooding Report dated February 1987.
(7) Estimated from Corps studies.

from their combined watershed areas of 1,788 square miles. In studies by the Corps in 1953 it was generally concluded, based on the flood history at that time, that floods on the Kennebec were produced largely by runoff from the watershed area downstream of Flagstaff and Moosehead Lakes, with these two lakes effectively controlling, or at least desynchronizing, flows from their watersheds, which represent 30 percent of the total Kennebec River watershed. It was further concluded that the mountainous Carrabassett and Sandy River tributaries were major contributors to flood peaks on the main stem Kennebec River. Since the flood of March 1953 and the Corps analysis at that time, there have been significant floods in the basin in December 1973, April 1979, April 1983, May/June 1984, and the recent major March/April 1987 event.

6. ANALYSIS OF FLOODS

In 1985 the Corps completed a report titled, "Hydrology of Floods, Kennebec River, Maine, Part I". Contained in that report are analyses of four recent Kennebec River flood events, namely: December 1973, April 1979, April 1983, and May/June 1984.

Available streamflow data from the U.S. Geological Survey plus data provided by the Kennebec Water Power Company was used for the flood analysis. Flood inflow hydrographs to the three principal storages: Brassua, Moosehead and Flagstaff Lakes, were computed using reported average daily outflows and daily changes in lake storage data in the continuity equation:

$$\text{Inflow} = \text{Outflow} + \Delta\ \text{Storage}$$

The resulting hydrographs at the storages, shown in the 1985 report, are approximate since they are based on average daily outflow and reservoir stage data. Hydrographs at USGS gaging stations are based on hourly data. Component outflow hydrographs were progressively combined and routed downstream. The routed hydrographs were checked for timing with USGS gaging station flow records. Hydrographs were subtracted from the recorded hydrographs to determine residual runoff hydrographs attributable to the intervening local areas.

Based on the analysis, the finally adopted travel times for hydrograph routing were as follows:

Reach	Travel Time (hours)
Lakes to Forks	4
Forks to Bingham	4
Bingham to Mouth of Carrabassett River	4
Carrabassett River to Skowhegan	4
Skowhegan to Waterville	4
Waterville to North Sidney	4

Resulting component contributions to peak floodflows on the Kennebec River from the Forks to Augusta, are shown graphically on plate 2 for the recent floods of 1973, 1979, 1983, and 1984. Component contributions in percent, at Bingham and North Sidney, are listed in table 4. For comparison purposes, percent component contributions are listed by: (a) drainage area, (b) typical peak discharge contributions as estimated in 1953 studies by the Corps, and (c) estimated peak discharge contributions, for the recent floods analyzed.

The flood of March/April 1987 was analyzed in "Hydrology of Floods, Kennebec River Basin, Maine, Part II". In that report component contributions were determined using provisional USGS streamflow and rainfall records. It is noted the final USGS report on the March/April 1987 flood had not been received during preparation of this reconnaissance investigation. This was a new flood of record generally throughout the mid to lower Kennebec Basin and, with the upper basin reservoirs completely controlling runoff from their contributing watersheds, dramatically demonstrated the flood producing potential of runoff from the uncontrolled downstream watersheds. Flood hydrographs and component contributions to peak flows, estimated and recorded, are shown graphically on plate 3.

In analyzing the 1987 flood, the local contribution hydrograph between the Forks and Bingham gages was computed by lagging the Forks hydrograph 1 hour and subtracting from the Bingham data. Component contributions at North Sidney were computed by lag/averaging the Bingham hydrograph 16/7 hours and lagging the Carrabassett and Sandy River hydrographs 12 hours. Component contribution in percent at Bingham and North Sidney for the 1987 flood are also listed in table 4.

In 1953 studies it was concluded that upper basin floodflow contributions were typically modified and desynchronized

TABLE 4

KENNEBEC RIVER
COMPONENT CONTRIBUTIONS
TO FLOOD DISCHARGES

Component	Drainage Area		Percent Contribution to Peak Flow						
	Sq. Miles	Percent	1953 Studies	1973 Flood	1979 Flood	1983 Flood	1984 Flood	1987 Flood	1973-1987 Avg. Flood
			At Bingham Gage						
Kennebec above the Forks	1,590	59	27	40	40	51	45	33	41
Dead River	874	32	35	32	35	26	40	30	33
Local	251	9	38	28	25	23	15	37	26
	2,715	100							
			At North Sidney Gage						
Kennebec above the Forks	1,590	29	7	14	12	22	24	10	16
Dead River	874	16	10	12	14	15	22	9	14
Local to Bingham	251	5	10	9	9	10	7	9	9
Carrabassett River	354	7	16	14	19	13	10	17	15
Sandy River	514	10	24	20	20	14	12	20	17
Sebasticook River	946	17	8	11	4	13	10	9	10
Local	874	16	25	20	22	13	15	26	19
	5,403	100							

by reservoir storage, as indicated by the then analyzed 1936 and 1953 flood events. However, in the five more recent floods, contribution from the upper basin was found to be more significant. The watershed area above Bingham represents 50 percent of the total area above North Sidney and its discharge contribution to the flow at North Sidney averaged about 39 percent during the five most recent floods (including March/April 1987), as compared to an estimated typical contribution of 27 percent in 1953. The uncontrolled mountainous Carrabassett and Sandy Rivers remain high floodflow contributors relative to size of drainage area.

7. DISCHARGE FREQUENCIES

a. General. Earliest streamflow data for the Kennebec River dates back to the 1890's with some unofficial data back to the early 1800's. Early data was recorded by dam operators on the river, principally the Hollingsworth and Whitney Company on the river at Waterville, Maine. The U.S. Geological Survey (USGS) began installing gaging stations in the basin in the early 1900's and have operated a system of gaging stations, at various sites and periods of time, continuously to date. USGS stations, pertinent to the analysis of Kennebec River floods and their respective periods of record, are listed in table 5.

b. Kennebec River. Peak discharge frequencies were developed for the Kennebec River by analysis of the long term gaging station at Waterville, Maine (DA = 4,270 square miles). The gaging station at Waterville has been discontinued; however, it has a continuous gaged record from 1892 to 1955 (64 years). In addition, from recent Corp studies, estimates of peak discharge at Waterville have been made for five recent flood events, including the major March/April 1987 flood. Therefore, in accordance with procedures presented in the Water Resources Council Bulletin 17B, the 64-year continuous record, along with the five recent flood events, were analyzed in a log Pearson Type III distribution. Results of analysis of the 69 years of data had a mean log 4.7149, standard deviation 0.2245, and a computed skew of 0.13. The regional skew of +0.3 was adopted. The computed curve at Waterville (DA = 4,270 square miles) was transferred downstream to Augusta (DA = 5,500 square miles) by the ratio of estimated and recorded flood peaks at the two locations, about a 15 percent increase. Peak discharge frequencies computed at Waterville were transferred upstream to Anson (confluence with the Sandy River) by straight drainage area ratio. To check for reasonableness of transferring computed discharges upstream by straight drainage area ratio the flood analyses of the five recent flood events was used. The ratio

TABLE 5

PERTINENT DATA - USGS GAGING STATIONS
KENNEBEC RIVER BASIN

Station	Drainage Area (sq. mi.)	Period of Record	Maximum Flow (cfs)
Kennebec River			
at Moosehead	1,268	1919-1982	16,700 - 3 May 1974
at Forks	1,590	1901-Present	30,300 - 1 Jun 1984
at Bingham	2,715	1908-1909 1931-Present	65,200 - 1 Jun 1984
at Waterville	4,270	1891-1954	154,000 - 19 Mar 1936
at N. Sidney	5,403	1978-Present	220,000 - Apr 1987
Dead River			
nr. Dead River	516	1939-1982	18,000 - 12 Sep 1954
at Forks	872	1910-1979	28,700 - 20 Mar 1936
'arrabasset River			
nr. North Anson	353	1926-Present	41,000 - Apr 1987
Sandy River			
nr. Mercer	514	1928-1979 +1987	38,600 - 19 Mar 1936 46,000 - Apr 1987
Sebasticook River			
nr. Pittsfield	572	1928-Present	17,500 - Apr 1987

of peak flows on the Kennebec at Anson to those at Waterville varies for individual flood events. However, reviewing the five flood events analyzed during the Part I and II studies, reveals that on average there is about a 10 percent increase in peak main steam Kennebec flows from Anson (confluence of the Sandy) to Waterville. Drainage area of the Kennebec at the Sandy is 3,850 square miles, while the drainage area at Waterville is 4,270 square miles, about a 10 percent increase. Therefore, it is considered that using a straight drainage area ratio is reasonable. Adopted discharge frequencies are shown on plate 4.

Computed discharge-frequencies at the main stem Kennebec gage at Bingham are also shown on plate 4. All discharge frequency analyses were conducted in accordance with procedures presented in the Water Resources Council Bulletin 17B, with resulting statistics shown on the individual curves. Comparing computed discharges at Bingham (2,715 square miles) to those adopted at Anson (mouth of Sandy River) reveal a considerable difference in peak runoff rates. The analysis of 58 years of record at Bingham results in a one percent chance (100-year) peak flow of about 80,000 cfs (29 csm). Whereas, the adopted one percent chance discharge at Anson (3,850 square miles) is about 170,000 cfs (44 csm), it is considered this large discrepancy is due to several factors: (1) peak flows at Bingham are affected more by available storage and regulation of the large upstream hydropower storage reservoirs, most notably, Brassua, Moosehead, and Flagstaff Lakes and, (2) peak flows at Anson are highly affected by uncontrolled runoff of the large contributing watersheds of the Carrabassett (401 sq. mi.) and Sandy (596 sq. mi.) Rivers.

c. Tributaries.

(1) Sandy River. Peak discharge-frequencies were developed for the Sandy River from analysis of the long term USGS gaging station at Mercer, Maine (DA = 514 square miles). This gaging station has a continuous period of record from 1929 to 1979 (51 years). In addition, the USGS has made estimates of the record 1987 peak flood flow on the Sandy River. The 52 years of record were analyzed in a Log Pearson Type III distribution resulting in a mean log 4.143, standard deviation 0.2179, and a computed skew of 0.04. The regional skew of 0.3 was adopted. This curve was then transferred upstream to Farmington by drainage area ratio and is shown on plate 4.

(2) Carrabassett River. Peak discharge frequencies were developed for the Carrabassett River by analysis of the

long term USGS gaging station at North Anson. This gage has a drainage area of 353 square miles and a continuous record from 1926 to 1987 (33 years). The 33 years of record were analyzed in a Log Pearson Type III distribution resulting in mean log 4.079, standard deviation of 0.217 and computed skew of 0.4. The resulting curve is also shown on plate 4.

(3) Sebasticook River. Peak discharge frequencies were developed for the Sebasticook River by analysis of the USGS gaging station near Pittsfield. The gage at Pittsfield (DA = 572 square miles) has a period of record from 1929 to 1987 (58 years). This data was analyzed in a log Pearson Type III distribution resulting in mean log 3.8166, standard deviation of 0.1576, and an adopted skew of +0.30. The computed curve was transferred upstream to Pittsfield by drainage area ratio to the 0.7 exponential power. Developed curves are shown on plate 4.

(4) Cobbosseecontee Stream. Peak discharge frequencies were also developed for Cobbosseecontee Stream at Gardner. The 84 years of record at the USGS gaging station were analyzed resulting in a mean log 3.311, standard deviation of 0.178, and an adopted skew of +0.5. The resulting curve is shown on plate 4.

8. FLOOD PROFILES

Flood profiles of the main stem Kennebec River for the March 1936 flood were developed during past Corps studies. These profiles from Gardner to Madison are shown on plates 8 to 14. The profiles were developed based on surveyed 1936 flood elevations. Also shown is an approximate low flow profile and the March/April 1987 flood elevations, as surveyed by the USGS. It is noted that while the profiles were originally developed in the 1950's, a cursory review of the major dams along the river with recent profiles presented in various flood insurance study reports, for the most part does not indicate any significant change in crest elevations of the dams. These profiles are presented to provide an indication as to the relative magnitude of the 1987 flood event as compared to the previous record flood of March 1936. In addition to these flood profiles, table 6, "Flood Elevations - Kennebec River," lists surveyed March 1936, March/April 1987 and computed 100-year flood elevations as determined by the Federal Emergency Management Agency (FEMA). It is noted that the FEMA 100-year elevations were determined before the major March/April 1987 flood event, with analysis conducted generally in the mid-1980's.

TABLE 6

FLOOD ELEVATIONS
KENNEBEC RIVER
(Feet NGVD)

River Mile	Community	1936	1987*	FEMA** 100 Year
36.8	Gardner/Randolph	26.5	24.7	28.5
40.9	Hallowell	29.6	29.1	-
43.6	Augusta D/S Dam	30.9	37.0	38
43.7	Augusta U/S Dam	35.4	38.4	38
55.2	N. Sidney Gage		54.3	-
61.4	Waterville D/S Dam	57.3	-	60
61.5	Waterville U/S Dam	65.0	-	66
62.5	Waterville D/S Dam	68.9	-	79
62.6	Waterville U/S Dam	87.3	-	88
65.0	Fairfield	95.1	100.6	96
68.4	Shawmut D/S Dam	105.2	110.0	108
68.4	Shawmut U/S Dam	118.5	120.4	120
81.5	Skowhegan D/S Dam	150.0	150.2	-
81.5	Skowhegan U/S Dam	162.5	173.2	164
85.9	Norridgewock	171.8	-	170
92.9	Mouth Sandy River	186.9	192.8	183
95.0	Madison D/S Dam	187.7	-	-
95.1	Madison U/S Dam	228.6	-	-
95.4	Madison D/S Dam	239.6	253.6	-
95.5	Madison U/S Dam	255.1	258.2	-

*Data provided by USGS.
**Approximate 100-year flood elevation determined from FEMA flood profiles.

9. STAGE FREQUENCIES

a. General. Stage-frequency relationships were developed at selected damage centers throughout the watershed. These curves were used by others to assess the damage potential at communities along the river. In general, curves were developed using computed discharge frequency relationships along with stage discharge curves developed from available flood profiles. The most notable exception to developing stage frequencies by this technique was the lower Kennebec generally from Augusta south to Gardner.

b. Augusta to Gardner. In reviewing surveyed flood elevations for the 1936 and 1987 flood events, apparent flood level discrepancies were noted. Surveyed flood elevations south of Augusta, and most notably at Gardner, were not consistent between the two events based on the magnitude of the respective peak discharges. This section of the Kennebec River is a long flat tidal estuary. Surveyed high watermark information is limited to the March 1936 and 1987 flood events. An attempt was made to analyze this reach of the river to determine if the surveyed high water elevations could be reproduced. Initially, it was considered that peak flood elevations along the lower Kennebec could be a function of flood runoff volume rather than peak discharge; therefore, the National Weather Service Dam-Break Flood Forecasting Program was utilized. The program has the capability of routing a flood wave through a downstream valley and gives information on flood attenuation, timing, and resulting peak flood elevations. Input to the model consisted of river cross sections as developed from the 1:62500 USGS quad sheets with river invert determined from the flood insurance study report profiles, assuming a triangular below water shape. Also input were Manning's roughness coefficients and expansion/contraction coefficients. The model was developed from downstream of the dam in Augusta to downstream of Richmond, a total river distance of about 22 miles.

Recognizing that the 1987 flood was unaffected by ice, this event was analyzed first. The observed hydrograph at the North Sidney gage was used as input and routed through this reach assuming channel control at the downstream boundary. Average Manning's "n" coefficient of 0.03 was used. Flood elevations computed at Gardner, Hallowell, and Augusta compared well with those surveyed.

The 1936 flood hydrograph, as observed at Waterville, was then analyzed with computed water surfaces much lower than those experienced. Various starting water surface elevations were assumed, along with a range of Manning's "n" coefficients; however, an adequate calibration of this event was not obtained. As a result, a review of available data was made.

The March 1936 flood was a two-peaked event with the initial peak occurring between the 13th and 14th of the month, and with the larger peak occurring 5 to 6 days later, between the 19th and 20th. Based on records at Waterville, the second peak was about 60 percent greater than the first. From information obtained in the USGS Water Supply Paper 798, "The Floods of March 1936, Part I, The New England Rivers", it can be noted that, in general, peak elevations upstream of Cushnoc Dam in Augusta occurred as a result of the second larger peak, as would be expected. However, peak elevations downstream of the dam, at Hallowell, Gardner, and Richmond all occurred on the morning of 14 March at/or around the first peak of the flood. A review of newspaper accounts and photographs confirms that a large ice jam existed during the first peak and did not go out until the 19th of March, just prior to the second peak. Also, it appears as though the first peak was occurring around high tide.

Due to the complex hydraulic nature of this reach of river and numerous uncertainties, stage frequencies were developed by assigning the two surveyed flood elevations (1936, 1987) Weibull plotting positions and a curve sketch using hydrologic engineering judgement. It is noted that while these curves do not differ appreciably from the elevations presented in the various flood insurance studies, the development technique for the two is not consistent. Adopted stage frequency curves for Gardner/Randolph, Hallowell and Augusta (Memorial Bridge) are shown on plate 5.

c. <u>Upstream of Augusta.</u> Stage frequency relationships were developed for the following communities along the main stem Kennebec:

Augusta (upstream Cushnoc Dam)
Waterville/Winslow
Fairfield
Skowhegan
Madison/Anson

Curves at these locations, with the exception of Madison/Anson, (shown on plate 5) were developed based on discharge rating curves developed from flood profiles presented in various flood insurance studies and adopted discharge-frequency relationships. The curve at Madison/Anson was developed based on surveyed high water marks of 1936 and 1987 and assigned plotting positions.

d. Farmington. Stage frequencies were developed along the Sandy River at Farmington, Maine. A discharge rating curve developed during past Corps studies was utilized along with computed discharge frequencies. The curve is shown on plate 5.

e. Pittsfield. There are no detailed flood profiles or topographic mapping available for the Sebasticook River in Pittsfield, Maine. Development of stage-frequency curves was reliant on surveyed flood elevations for the 1936 and 1987 flood events, hydrologic engineering judgement and the limited data presented in a Phase I inspection report for Pioneer Dam in Pittsfield. Estimated curves are shown on plate 6.

10. FLOOD CONTROL ALTERNATIVES

a. General. The Kennebec River is subject to frequent and major flooding. Many communities were identified that have the potential for significant flood damage. Several flood control alternatives were examined to determine economic feasibility.

b. Flood Control Reservoirs. Previous Corps hydrologic studies analyzed the component contribution of various subwatersheds and determined the Sandy and Carrabassett Rivers to be major contributors to peak Kennebec River flows. At the request of the State of Maine, these watersheds were examined to determine if feasible flood control reservoir sites exist. Additional areas were not analyzed because of low component contribution or constraints within subwatersheds which limit reservoir development.

(1) General. The Corps has constructed 35 dams within the New England Division. In studies during the design of this system of reservoirs it was found that flood control storage capacity from 6 to 8 inches of runoff from the contributing watershed was a reasonable amount of storage for flood control purposes.

(2) Sandy River. The Sandy River, with a total drainage area of 596 square miles, has been investigated for possible reservoir sites in the past. During the NENYIAC studies this watershed was investigated for a potential hydropower storage project. The proposed Greenleaf dam project site, with a drainage area of 513 square miles, is located about 9 miles above the mouth of the river between the communities of Starks and Mercer. In current studies this site was investigated for use as a potential flood control reservoir. The Greenleaf dam, as proposed for

hydropower use, would have been about 125 feet high and have impounded approximately 160,000 acre-feet of storage. Therefore, utilizing 160,000 acre-feet for flood control storage would result in 5.9 inches of runoff from the upstream watershed. In determining storage requirements for a flood control reservoir, the 5.9 inches of runoff was considered adequate for a reconnaissance investigation. The main dam would consist of a rolled earth section about 3,400 feet long. In addition, four earth dikes, of moderate height, would be required to close the reservoir perimeter. As originally planned, the Greenleaf project would have had a remote spillway located in a low saddle which would have discharged into Lemon Stream. Spillway length and maximum surcharge have not been determined; however, placing spillway crest at elevation 320 feet NGVD would provide the 160,000 acre-feet of flood control storage and establishing top of dam at elevation 340± feet NGVD would allow for 20 feet of spillway design surcharge and freeboard. This reservoir would require land taking of about 4,500 acres at spillway crest elevation.

(3) Carrabassett River. The Carrabassett River with a total drainage area of 401 square miles was reviewed. Starting at the mouth of the river at the community of North Anson, the Carrabassett appears to be relatively steep falling rapidly to the Kennebec. Proceeding upstream the river slope flattens somewhat and the river appears to have relatively low overbanks. Within this area there does not appear to be any well defined dam sites. Proceeding upstream, about 3 miles past the USGS gaging station, the river passes between two large hills along the border between the towns of New Portland and Embden, about 1 mile above Big Brook; this appears to be a relatively well defined dam site. About one mile upstream from this location a major tributary (Gilman Stream, DA = 94 square miles) joins the Carrabassett. Therefore, a reservoir upstream of the confluence with Gilman Stream would lose much of its effectiveness. Lemon Stream (DA = 34 square miles) enters at New Portland, and the Carrabassett at Kingsfield has a drainage area of 165 square miles. All of these factors lead to the most logical site upstream of the gage.

Analysis of the USGS 20-foot contour mapping indicates that the river has an invert of about 330 feet NGVD at this location, and a drainage area of about 350 square miles. Therefore, to provide storage equivalent to 6 inches of runoff (112,000 acre-feet) from the upstream watershed for flood control, a dam about 90 feet high (330 to 420 feet NGVD) would have to be constructed. Storage capacity between 330 to 405± feet NGVD would represent about 6.0 inches of runoff. Allowing 15 feet for spillway design, surcharge and freeboard would put top of the dam at elevation 420 feet NGVD. This dam would be about 1,800 feet long with an estimated reservoir area at spillway crest of 8,000 acres.

(4) Effect of Flood Control Reservoirs. The effect of flood control reservoirs located along the Sandy and Carrabassett Rivers on Kennebec River discharge frequencies was examined. Component analysis of the five recent floods was reviewed. As can be seen on plates 2 and 3, the contributions of the Sandy and Carrabassett Rivers vary for individual flood events. The computed discharge frequency curve at Waterville was analyzed. The five recent flood events were assigned Weibull plotting positions based on the estimated magnitude of their respective peak discharge at Waterville. Plotting positions for these flood events ranged from about a 1 percent chance for the 1987 flood to about 15 percent chance for the April 1983 flood. Once plotting positions were assigned, component contribution of the Sandy and Carrabassett Rivers for each individual flood event were determined from the analyses present on plates 2 and 3. Peak discharges at Waterville were then reduced by the amount of the respective component contribution. A representative modified discharge-frequency curve was then sketched through the modified five events. This curve is shown on plate 7. This technique was used for the three adopted main stem Kennebec River discharge-frequency curves (Anson, Waterville, North Sidney). Modified stage-frequency curves were then developed using the appropriate modified discharge frequency curve and previously developed rating curves. These modified stage-frequency curves are shown on plate 5.

c. Dikes/Walls. A series of dikes/walls were investigated for the following communities in the Kennebec River basin:

Kennebec River	Sandy River	Sebasticook River
Gardner	Farmington	Pittsfield
Hallowell		
Augusta		
Waterville		
Winslow		
Fairfield		
Skowhegan		
Anson		
Madison		

Alternative protective schemes were investigated for 50 and 100-year levels of protection at each community. Descriptions of proposed plans are included in the main report.

Interior drainage requirements for individual plans were not determined for this reconnaissance study. If any plan indicates economic feasibility a more detailed hydrologic assessment would be required.

d. Channel Improvements. Channel improvements were not investigated along the Kennebec River because the river has a relatively flat slope and depths of flooding are quite high (20 to 30 feet). Also, this river has a wide flood plain area that generally spans the valley cross section. It is considered that required channel improvements would be quite extensive and for those areas having the highest damage potential (i.e., Gardner), channel improvements do not appear to be economically feasible.

e. Flood Warning Time. A flood warning system is being evaluated as a component of nonstructural flood reduction measures. While the Kennebec River Basin is quite large, floods can develop quickly from uncontrolled runoff from the mountainous terrain south of Bingham, as experienced in 1987. The resulting warning time at Augusta for an event similar to 1987 would be about 12 to 24 hours.

11. SUMMARY/CONCLUSIONS

a. General. The Kennebec River experienced a major flood in March/April 1987. This was a new flood of record generally throughout the mid to lower Kennebec River Basin. Flooding occurred along the main steam Kennebec generally from Anson/Madison south to Gardner/Randolph. Major damage centers appear to be Augusta, Hallowell, and Gardner. In addition to flooding that occurred along the main stem Kennebec, flooding was experienced along the tributaries, Sandy and Sebasticook Rivers. Along the Sandy the community of Farmington was particularly hard hit while Pittsfield, located along the Sebasticook, also experienced flood damage.

b. Flood Control Reservoirs. At the request of the State of Maine, it was attempted to locate flood control reservoir sites along the major flood contributing subwatersheds of the Sandy and Carrabassett Rivers.

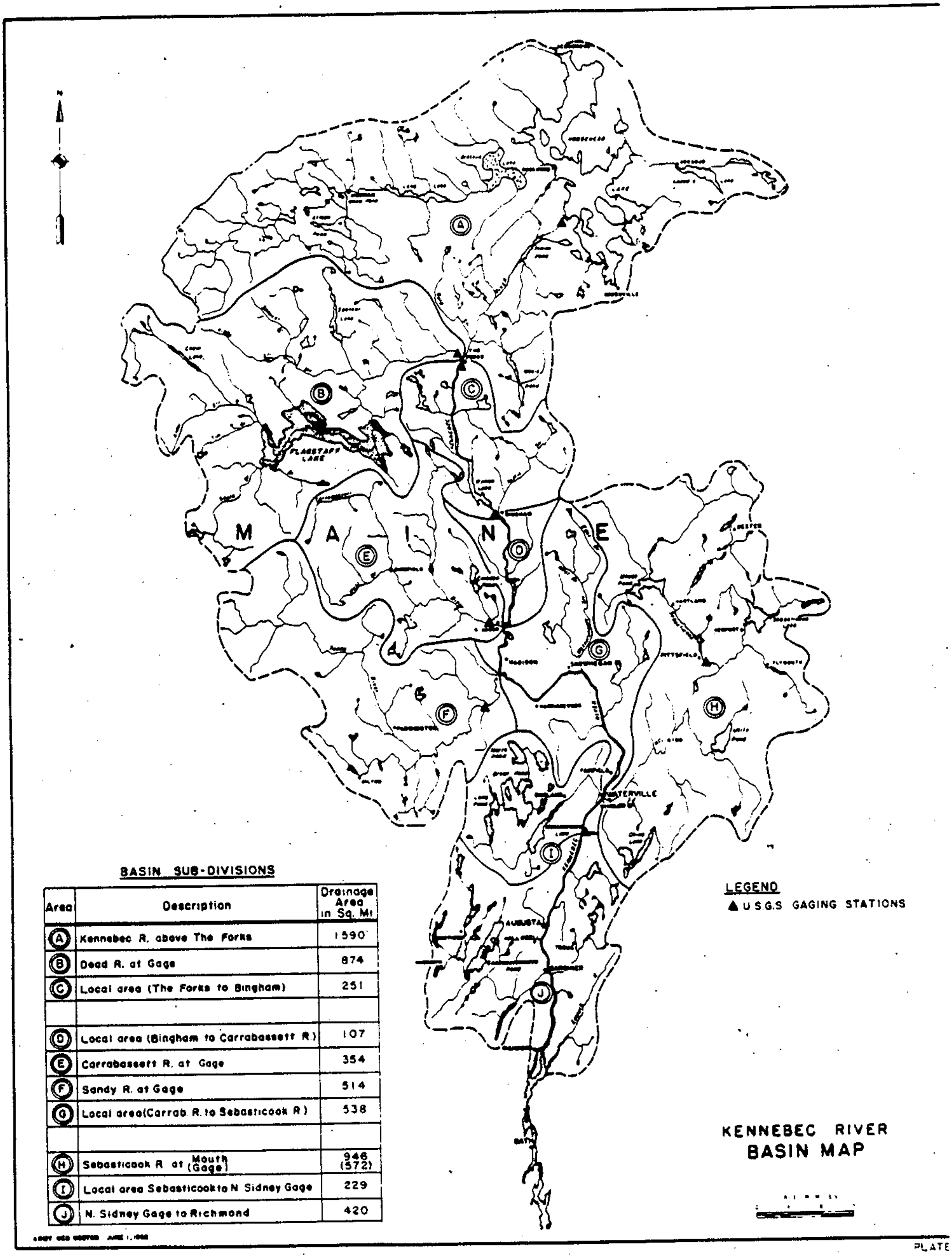
(1) Sandy River. A hydropower storage site, investigated during the NENYIAC studies was reviewed as to its potential for a flood control reservoir. The Greenleaf dam project would be located between the communities of Starks and Mercer. A dam 125 feet high would be capable of impounding 160,000 acre-feet (5.9 inches of runoff from the 513 square mile watershed) for flood control storage. The main dam would be about 3,400 feet long and four dikes would

be required to close the reservoir perimeter.

(2) Carrabassett River. A possible reservoir site was located about 3 miles upstream of the USGS gaging station near the community of North Anson. Approximate drainage area of this site is 350 square miles. To provide storage equivalent to 6 inches of runoff (112,000 acre-feet) a dam about 90 feet high and 1,800 feet long would be required.

c. Walls/Dikes. A series of walls and dikes were investigated for communities experiencing flooding problems. Descriptions of various schemes are contained in the main report.

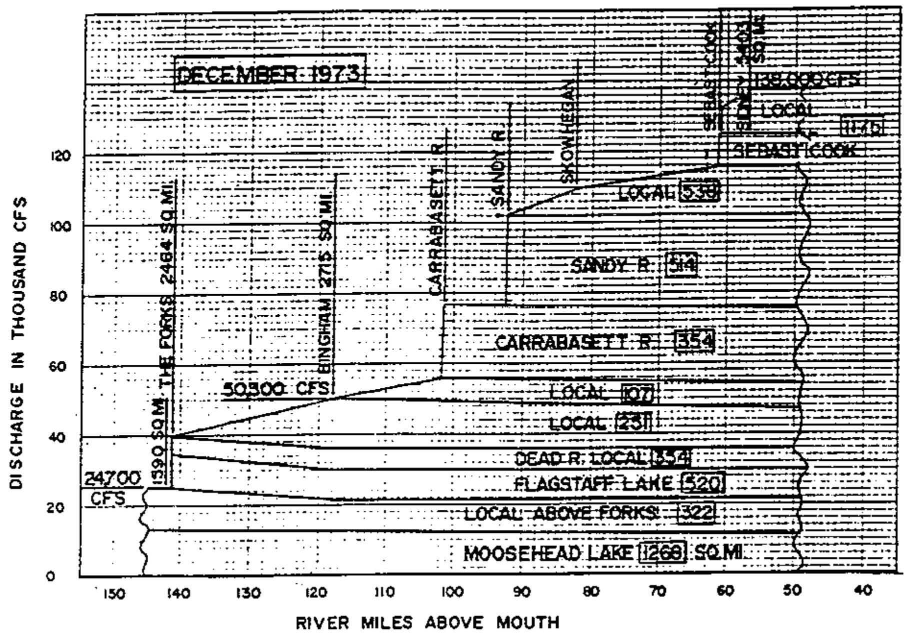
d. Discharge-Frequencies. Discharge frequency analysis conducted by the Corps for this reconnaissance utilized gaged records from the long term USGS gage at Waterville, plus estimates of recent flood events, including the major March/April 1987 flood. Results of this analysis indicate discharges somewhat greater than those used by FEMA while conducting the various flood insurance studies.

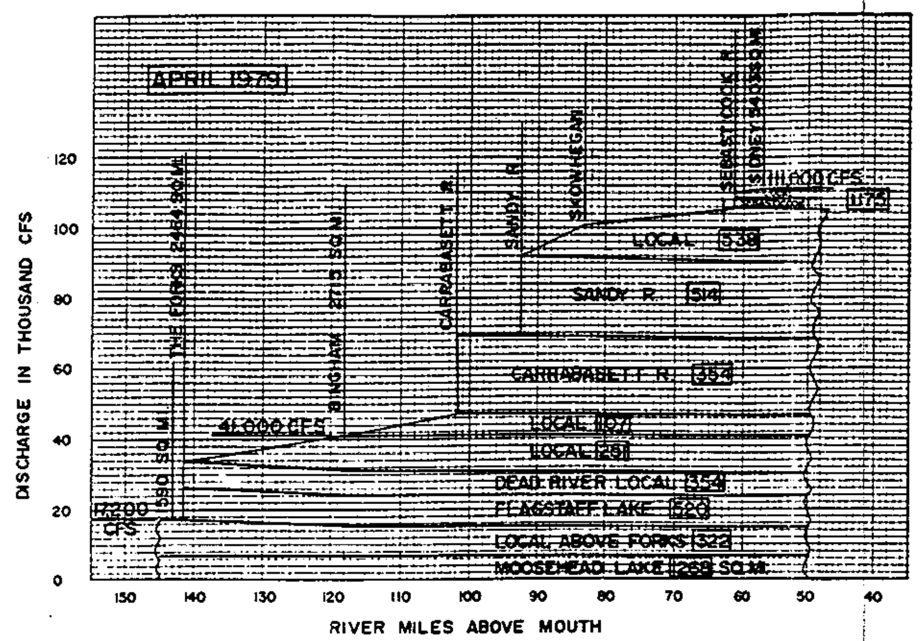


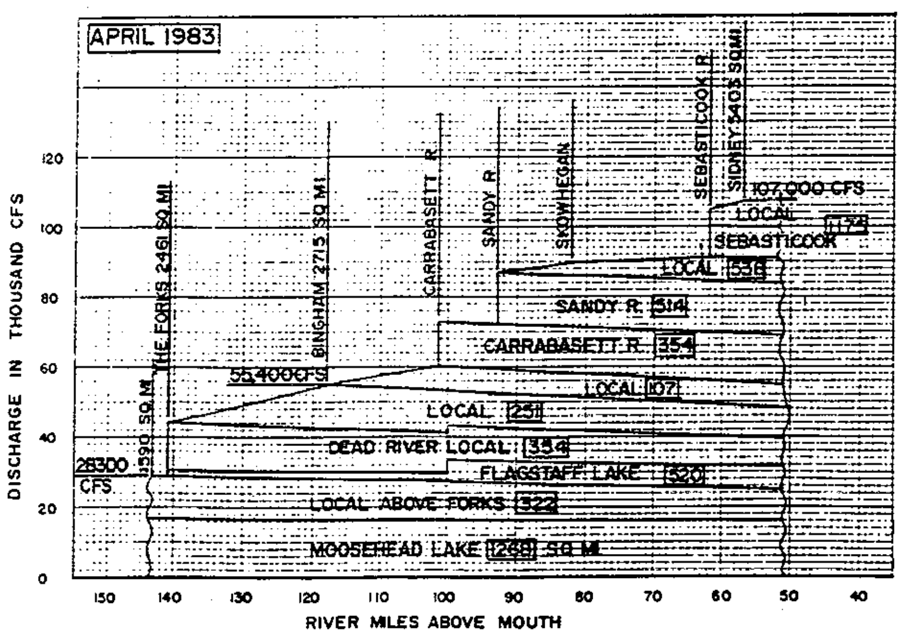
BASIN SUB-DIVISIONS

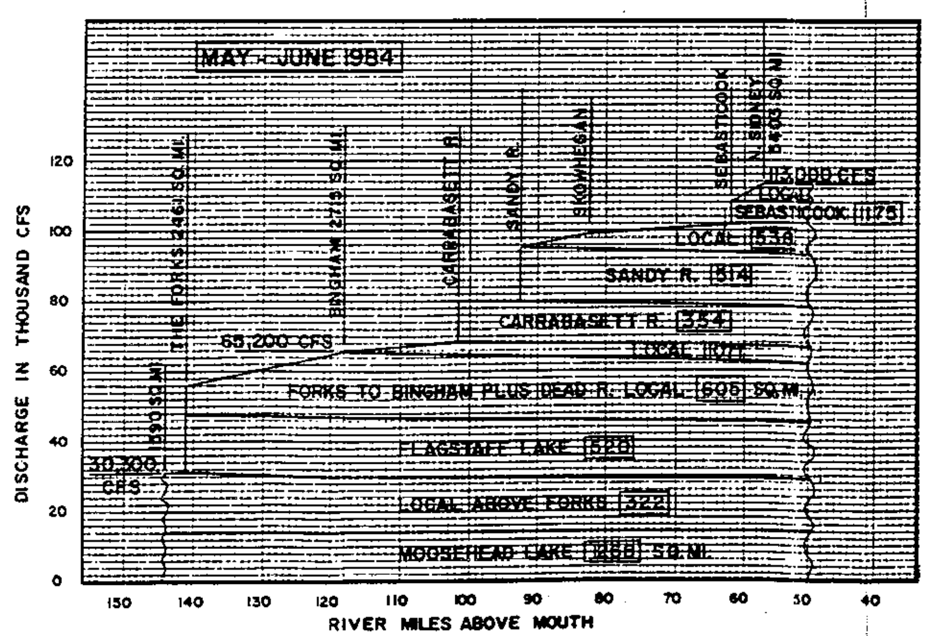
Area	Description	Drainage Area in Sq. Mi.
A	Kennebec R. above The Forks	1590
B	Dead R. at Gage	874
C	Local area (The Forks to Bingham)	251
D	Local area (Bingham to Carrabassett R.)	107
E	Carrabassett R. at Gage	354
F	Sandy R. at Gage	514
G	Local area (Carrab. R. to Sebasticook R.)	538
H	Sebasticook R. at Mouth (Gage)	946 (572)
I	Local area Sebasticook to N. Sidney Gage	229
J	N. Sidney Gage to Richmond	420

PLATE
1







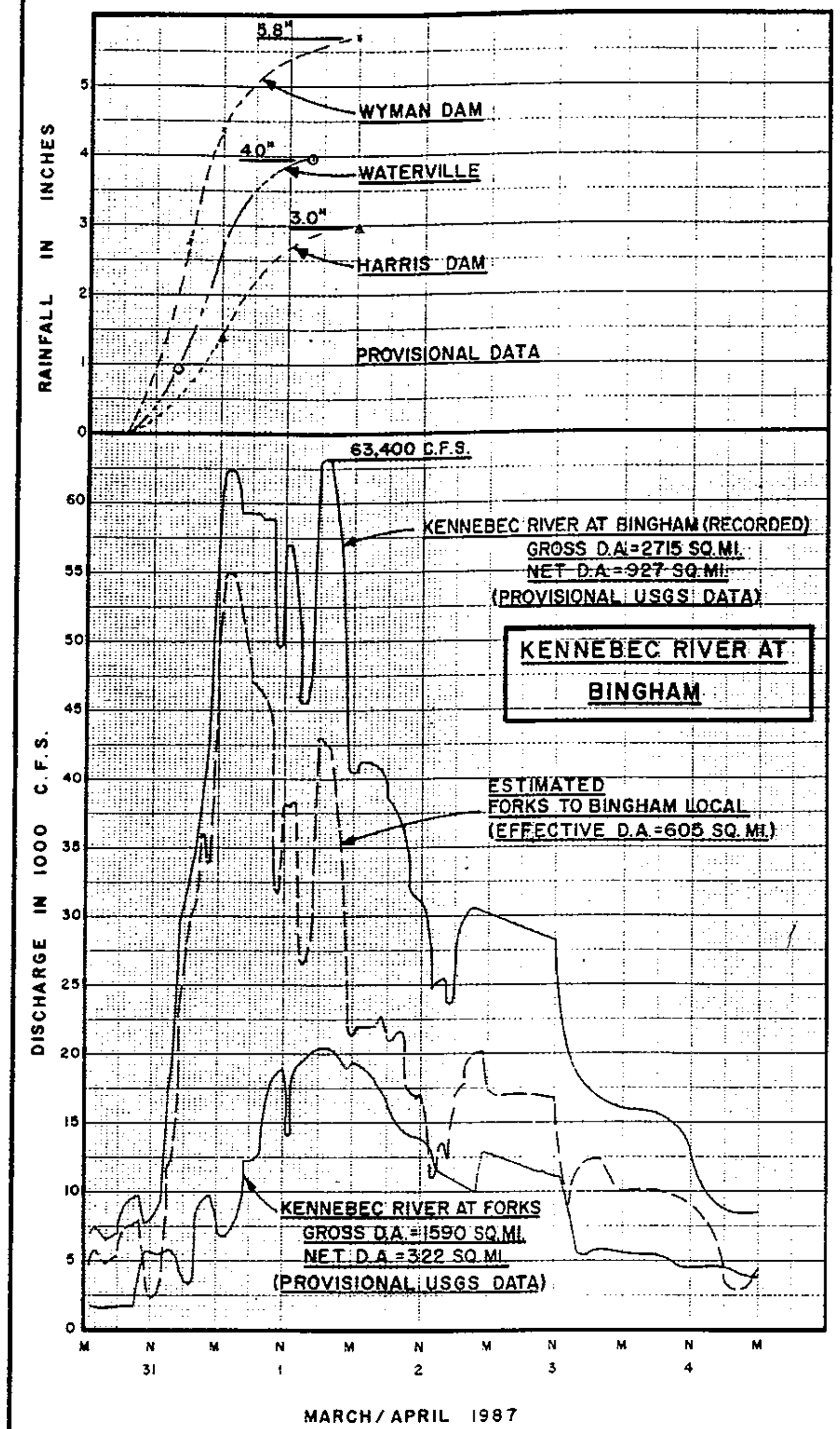


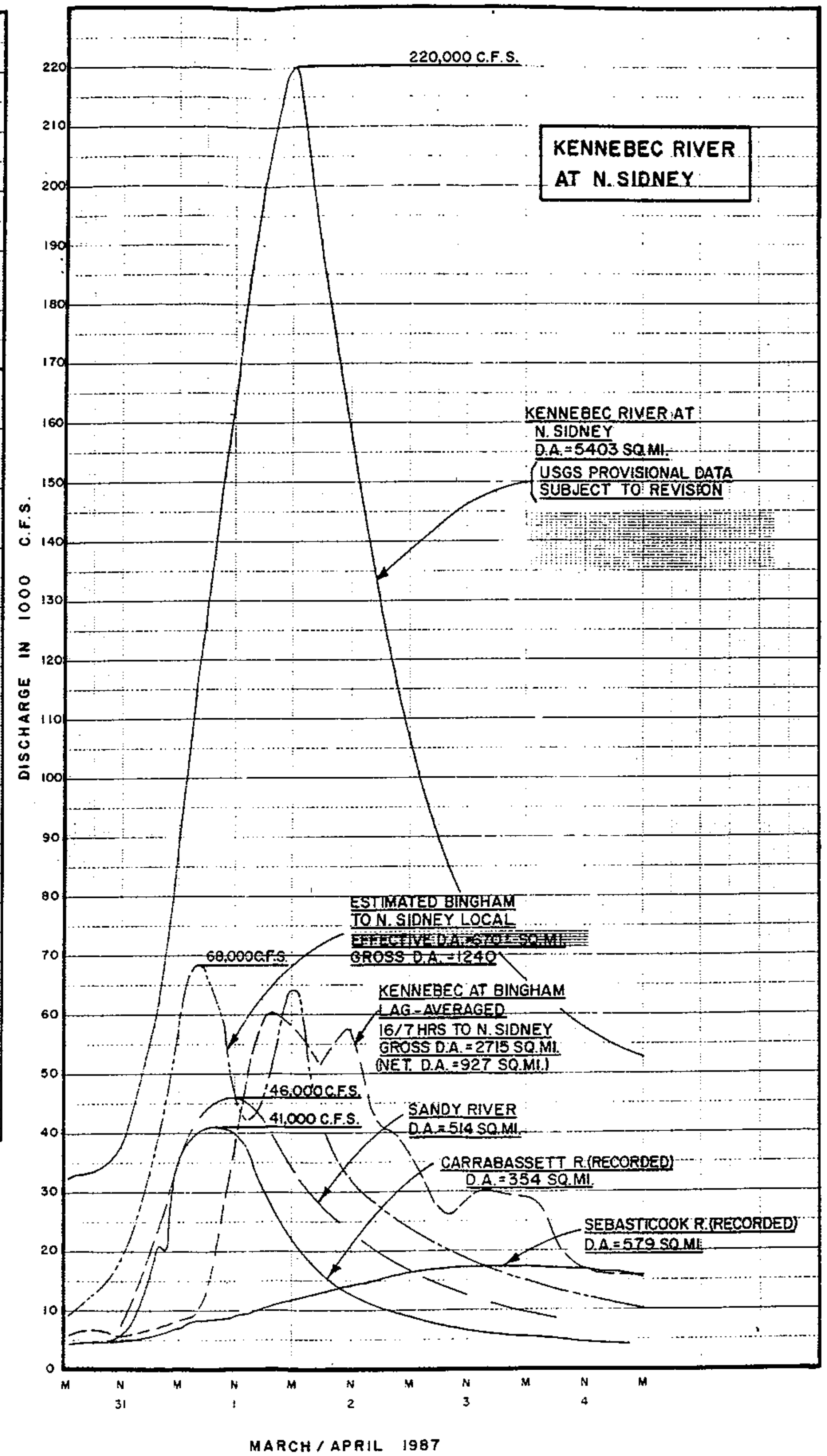
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

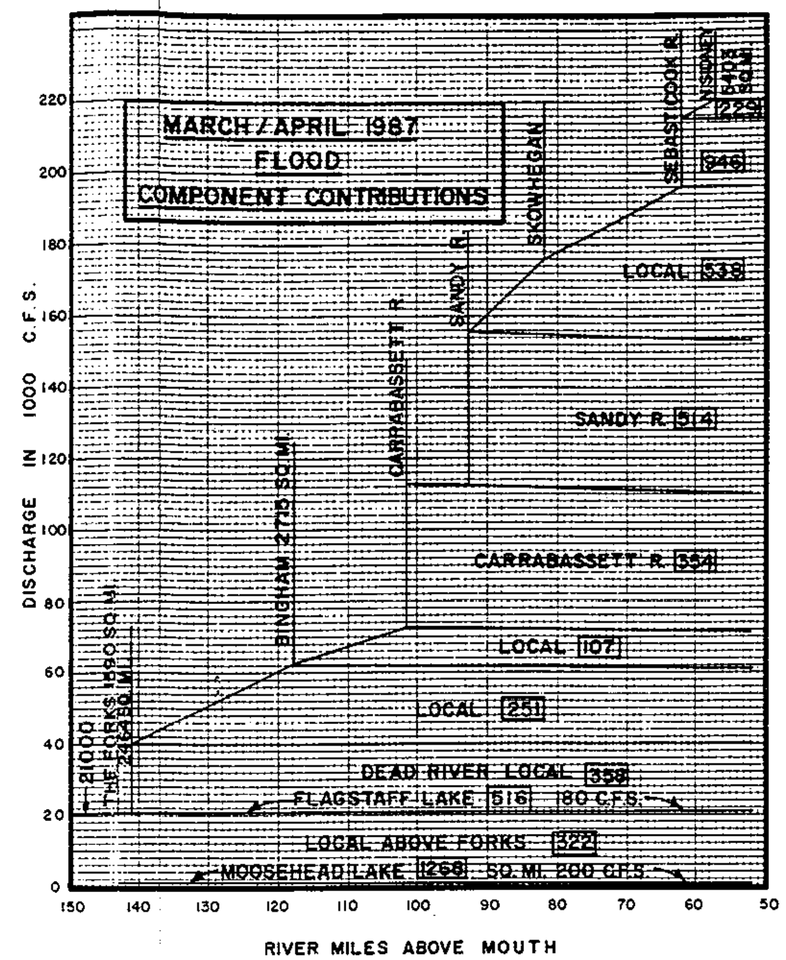
KENNEBEC RIVER BASIN
FLOOD DISCHARGE PROFILES
AND
COMPONENT CONTRIBUTIONS

KENNEBEC RIVER, MAINE

PLATE 2





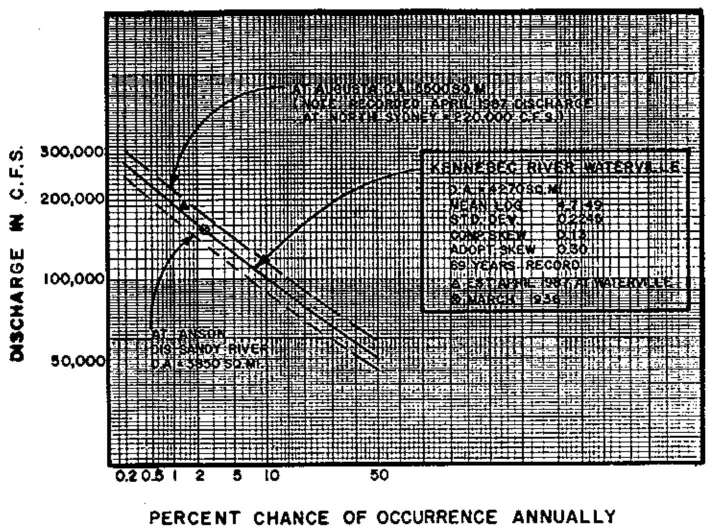


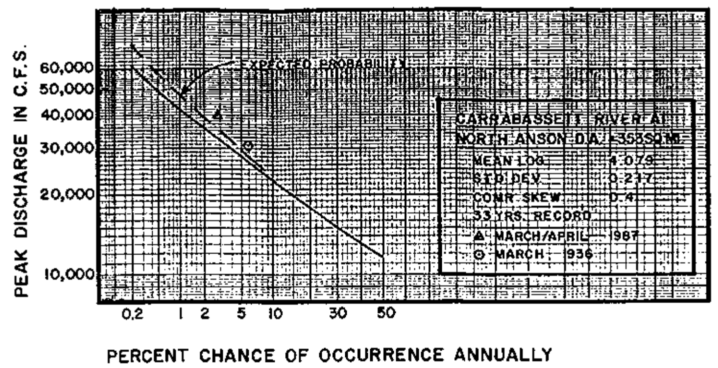
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

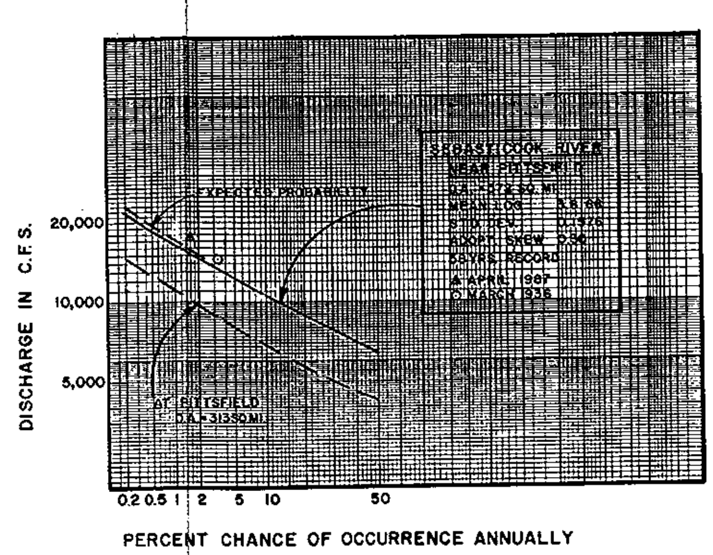
KENNEBEC RIVER BASIN

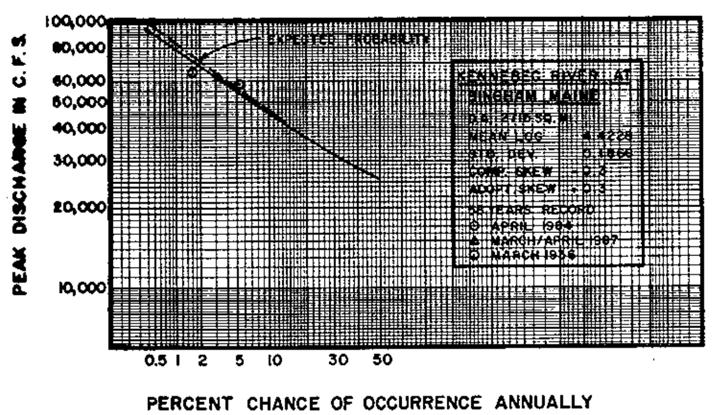
FLOOD ANALYSIS

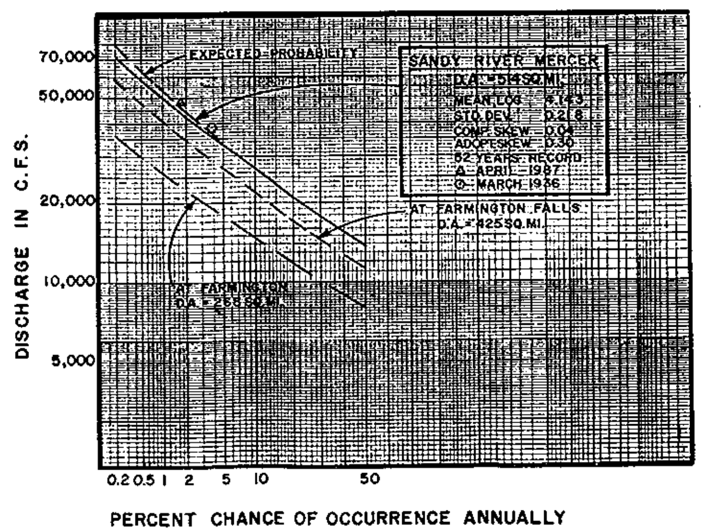
MARCH - APRIL 1987

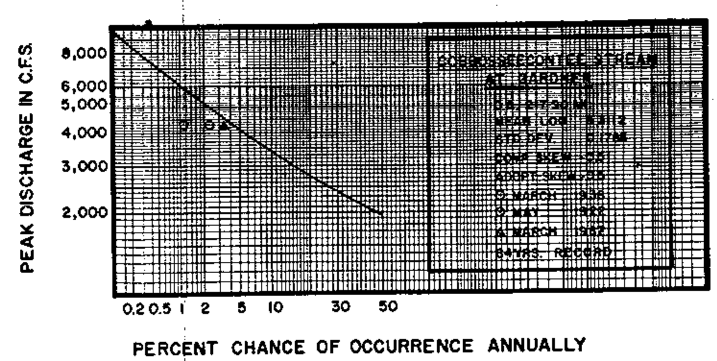












DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

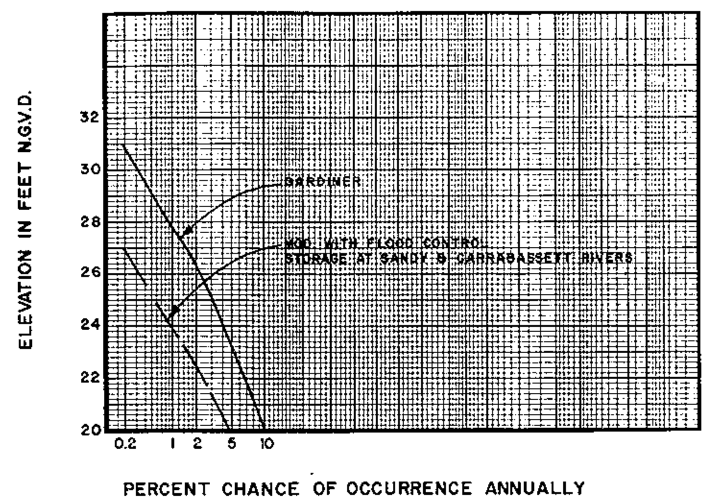
KENNEBEC RIVER BASIN MAINE

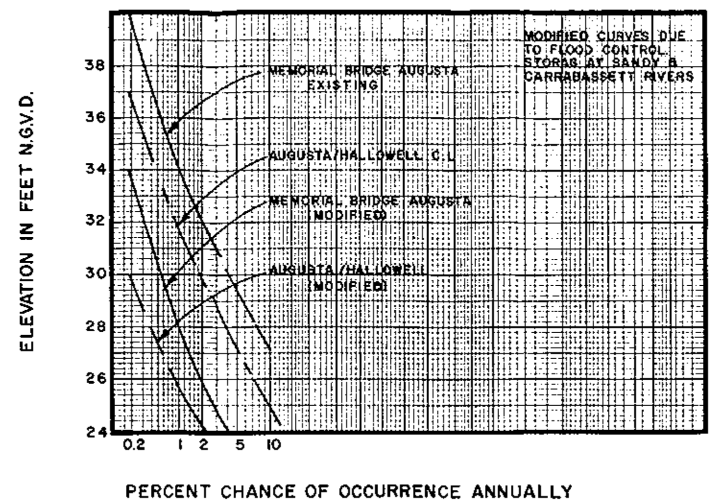
HYDROLOGIC RECONNAISANCE REPORT

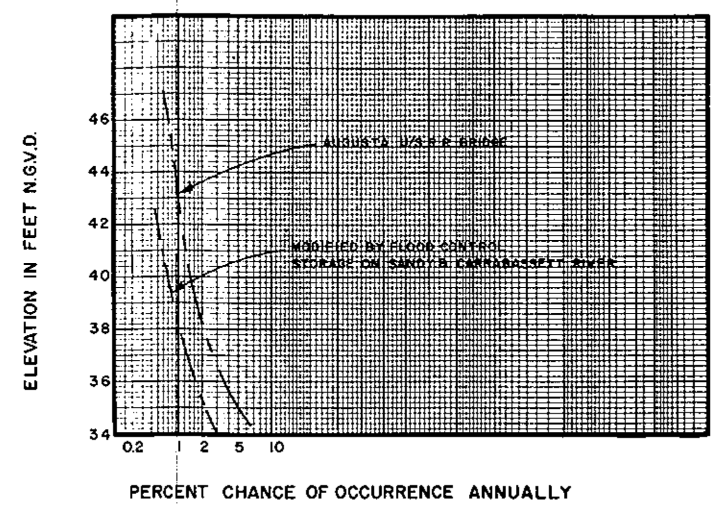
PEAK DISCHARGE FREQUENCY CURVES

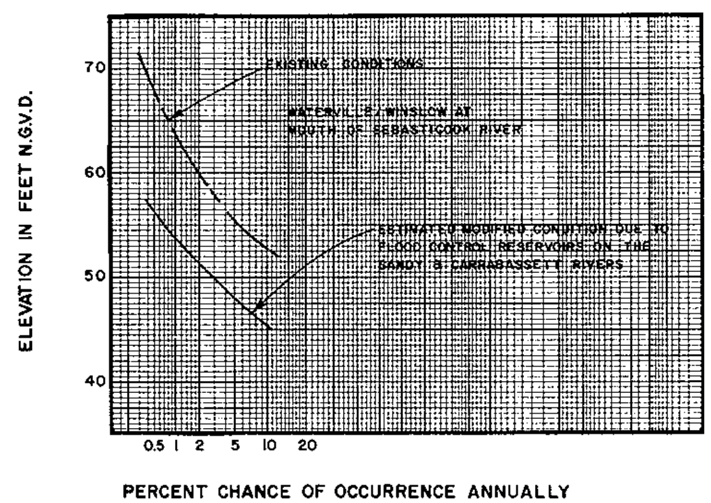
HYDRO. ENGR. SECT. NOV. 1988

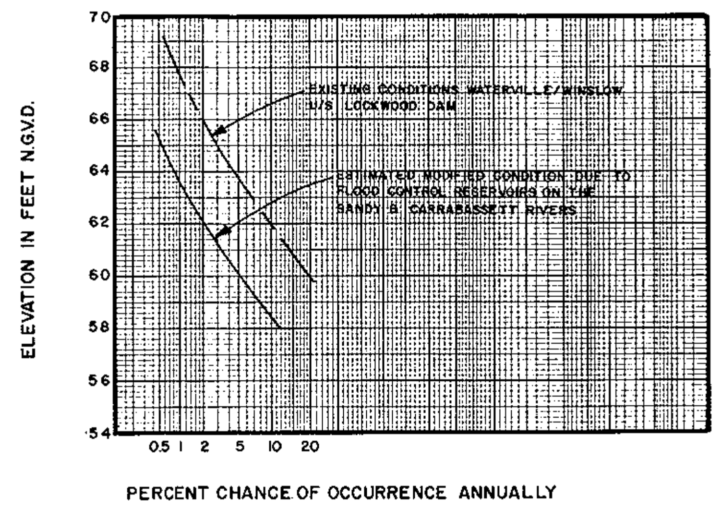
PLATE 4

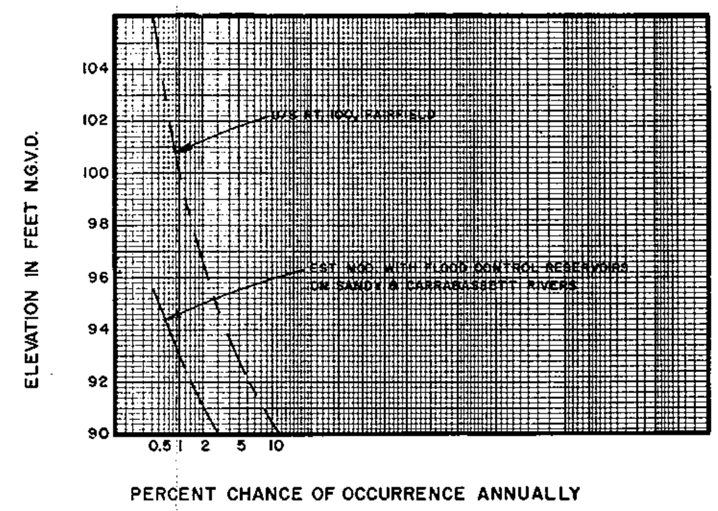


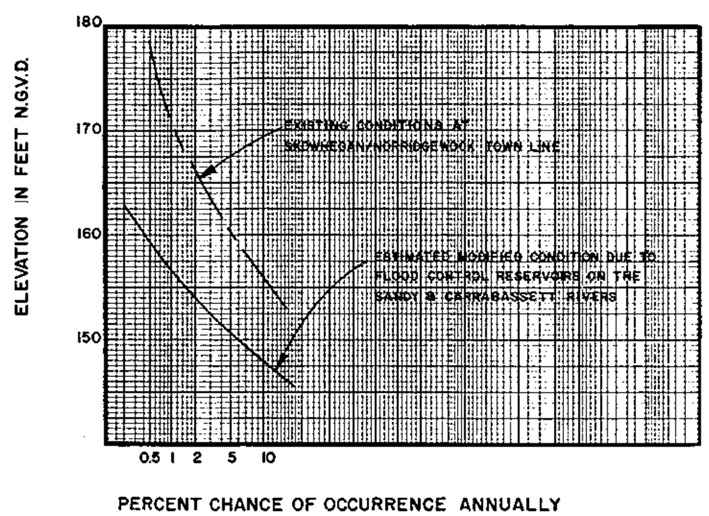


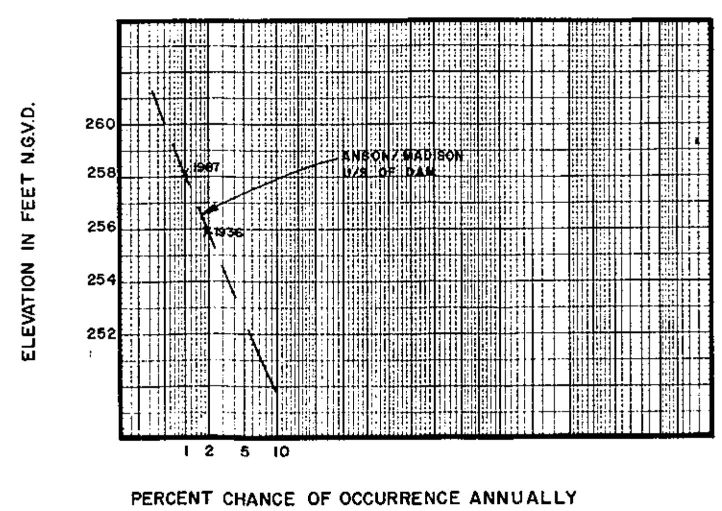












DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

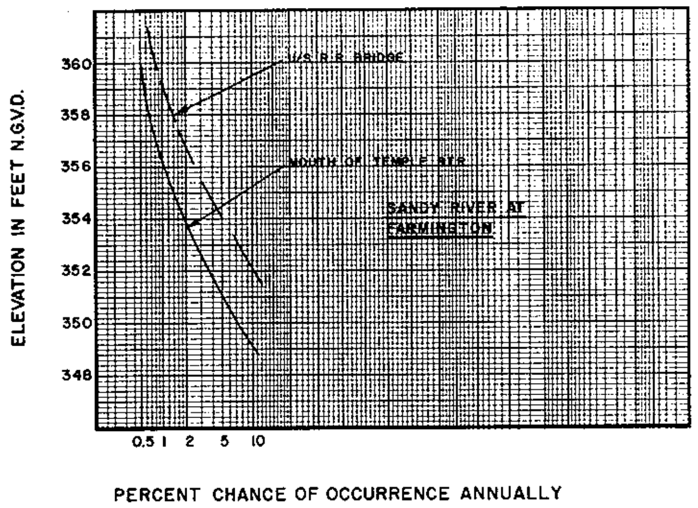
KENNEBEC RIVER BASIN MAINE

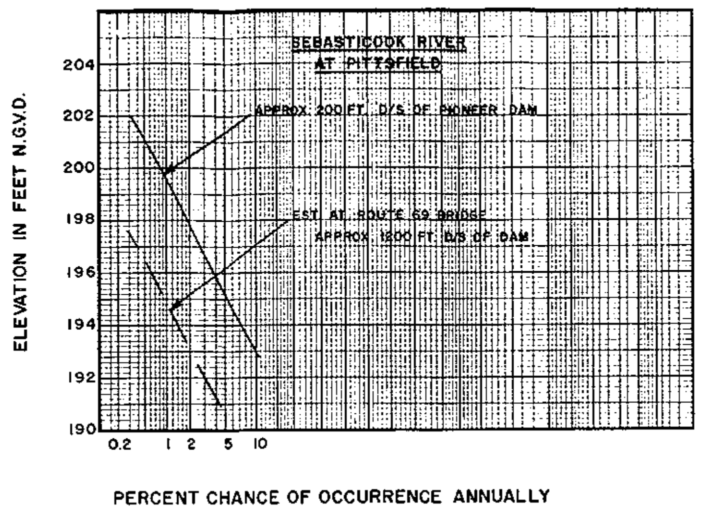
MAIN STEM KENNEBEC

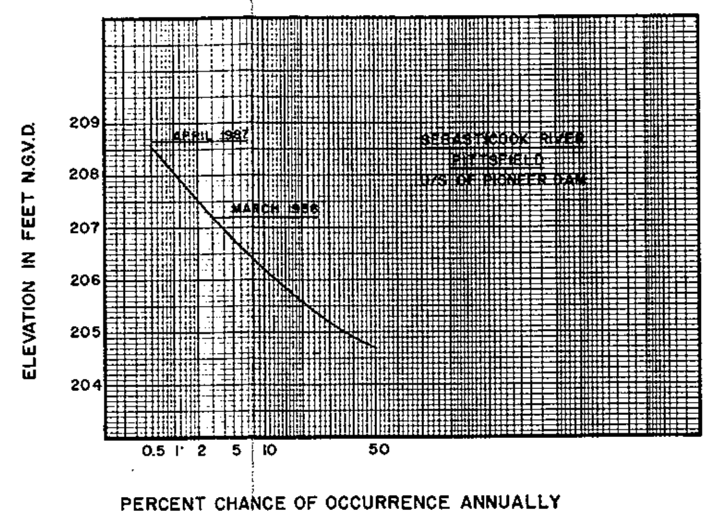
STAGE FREQUENCY CURVES

HYDRO. ENGR. SECT. NOV. 1988

PLATE 5







DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

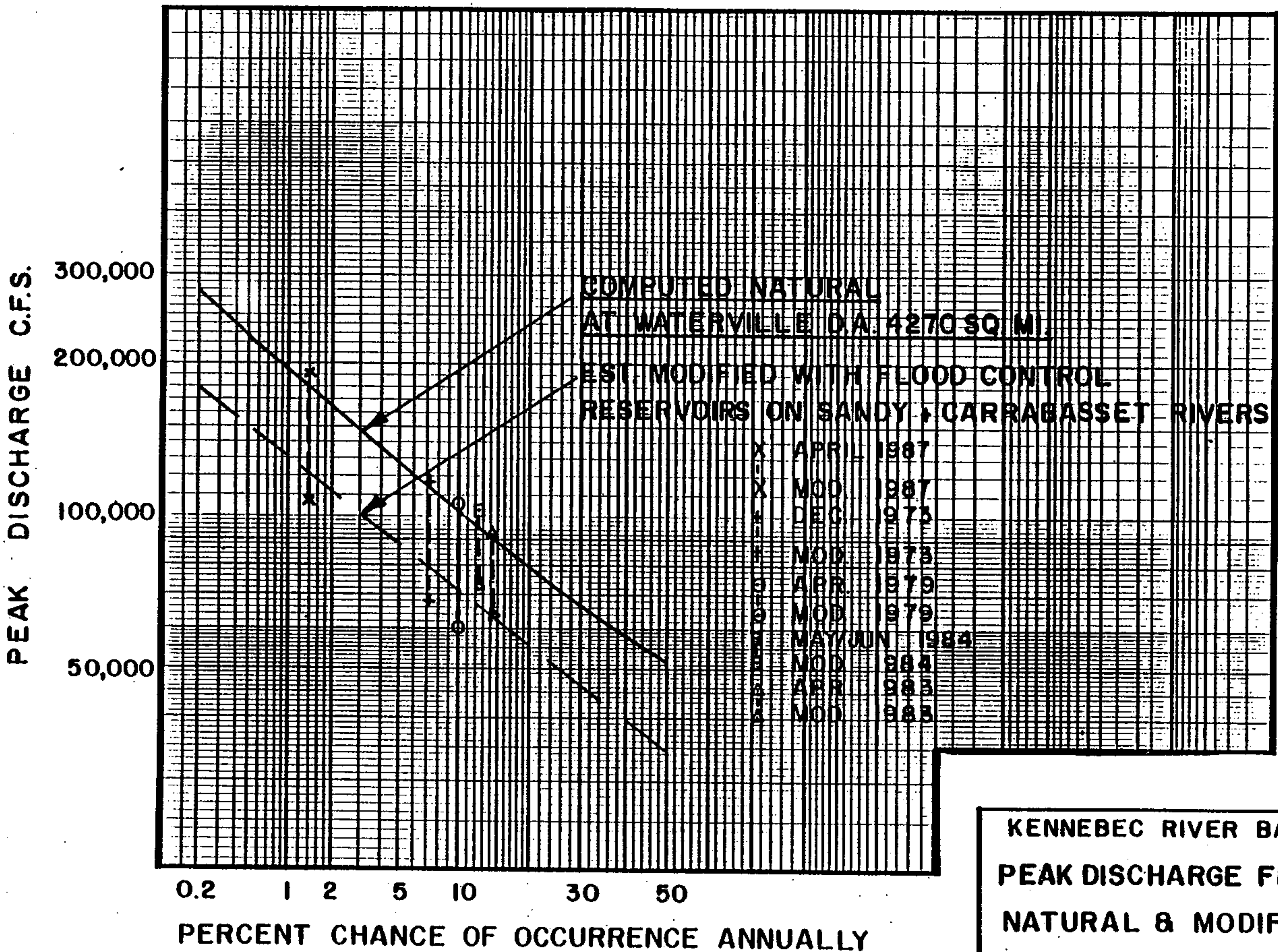
KENNEBEC RIVER BASIN MAINE

HYDROLOGIC RECONNAISANCE REPORT

STAGE FREQUENCY CURVES AT FARMINGTON AND PITTSFIELD

HYDRO. ENGR. SECT. NOVEMBER 1988

PLATE 6



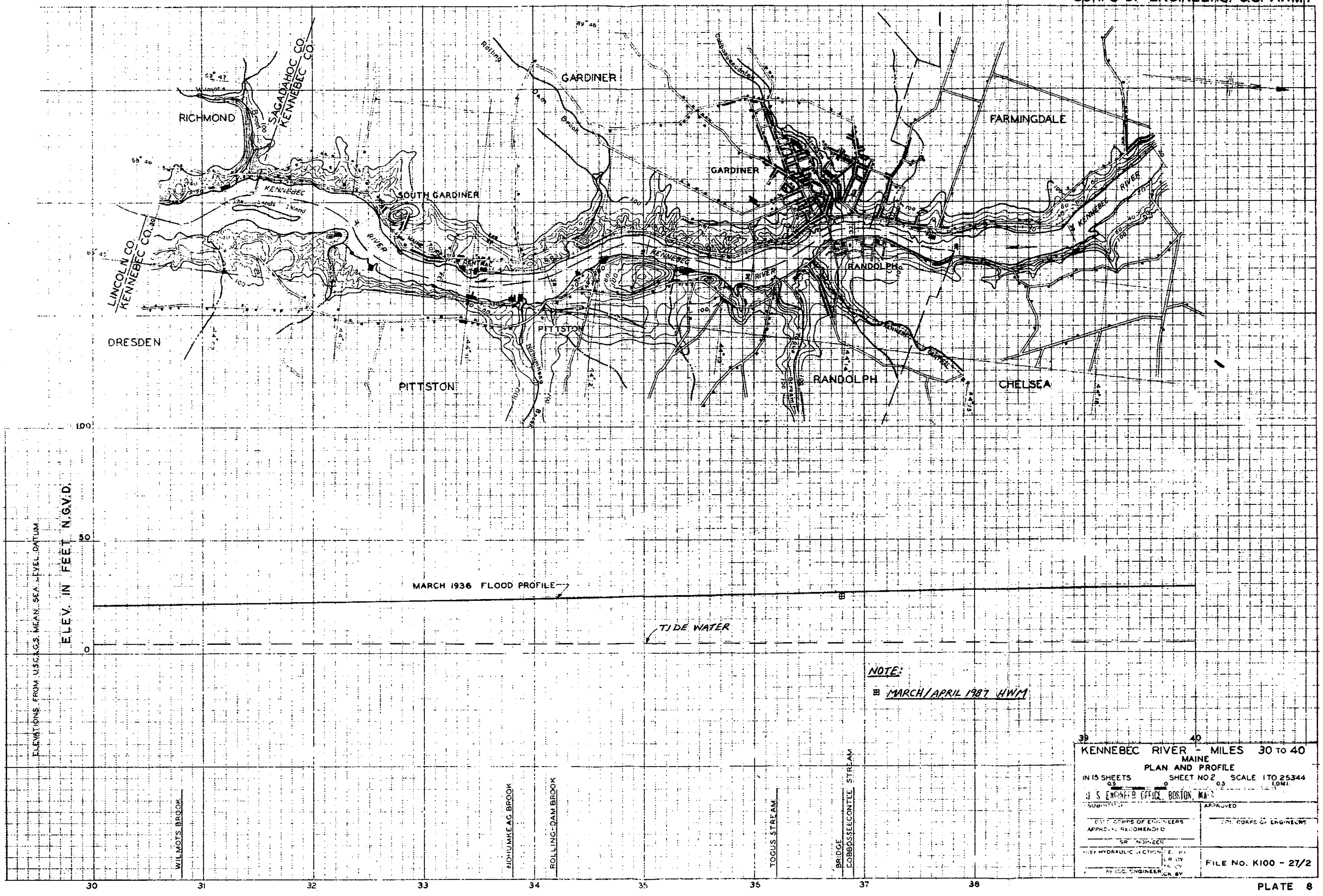
KENNEBEC RIVER BASIN

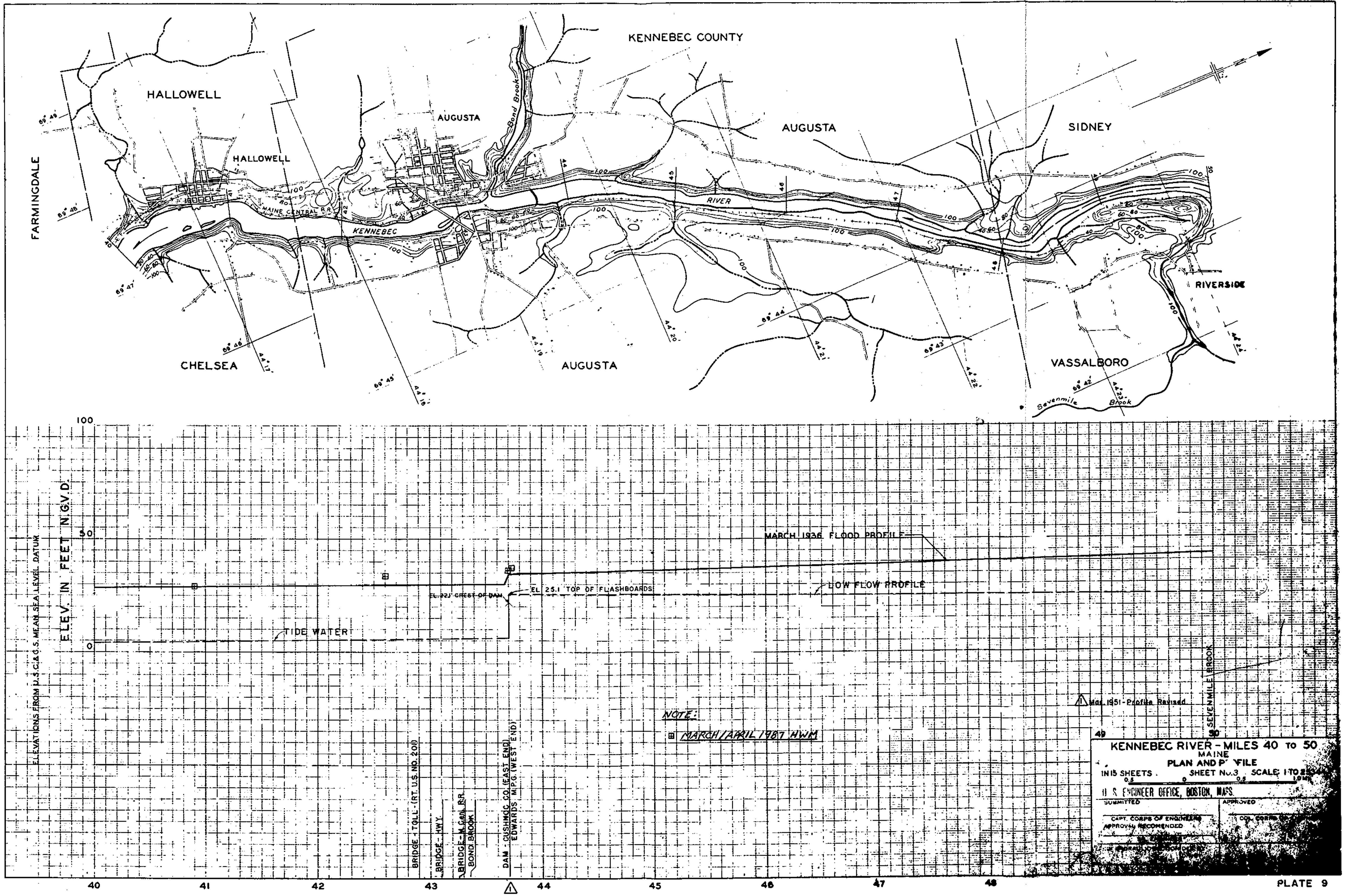
PEAK DISCHARGE FREQ.

NATURAL & MODIFIED

HES NOV. 1988

PLATE 7


RICHMOND
SAGADAHOC CO.
KENNEBEC CO.
GARDINER
FARMINGDALE
SOUTH GARDINER
KENNEBEC RIVER
LINCOLN CO.
KENNEBEC CO.
RANDOLPH
DRESDEN
PITTSTON
CHELSEA
ELEVATIONS FROM U.S.C.&G.S. MEAN SEA LEVEL DATUM
ELEV. IN FEET N.G.V.D.
100
50
0
MARCH 1936 FLOOD PROFILE
TIDE WATER
NOTE:
⊞ MARCH/APRIL 1987 HWM
WILMOTS BROOK
NOHUMKEAG BROOK
ROLLING-DAM BROOK
TOGUS STREAM
BRIDGE
COBBOSSEECONTEE STREAM
30
31
32
33
34
35
36
37
38
39
40
KENNEBEC RIVER - MILES 30 TO 40
MAINE
PLAN AND PROFILE
IN 15 SHEETS
SHEET NO 2
SCALE 1 TO 25344
U.S. ENGINEER OFFICE, BOSTON, MASS.
SUBMITTED
APPROVED
CORPS OF ENGINEERS
APPROVAL RECOMMENDED
SR. ENGINEER
HYDRAULIC SECTION
CORPS OF ENGINEERS
ENGINEER
FILE No. K100 - 27/2



KENNEBEC RIVER - MILES 40 TO 50
MAINE
PLAN AND PROFILE
IN 15 SHEETS . SHEET No. 3 SCALE: 1 TO
U. S. ENGINEER OFFICE, BOSTON, MASS.
SUBMITTED
APPROVED
CAPT. CORPS OF ENGINEERS
APPROVAL RECOMMENDED
COL. CORPS OF

CORPS OF ENGINEERS, U.S. ARMY

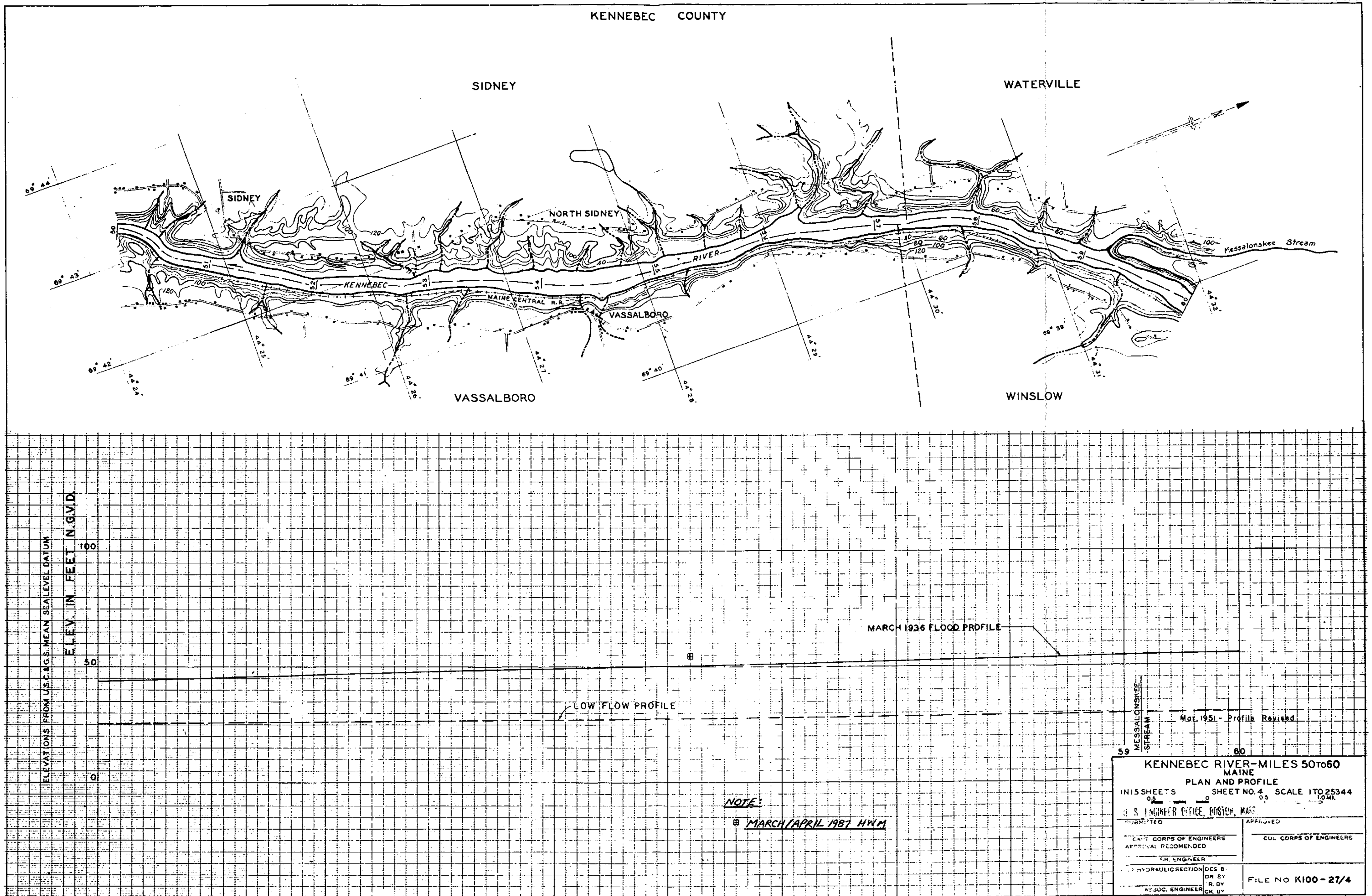


PLATE 10

CORPS OF ENGINEERS U.S. ARMY

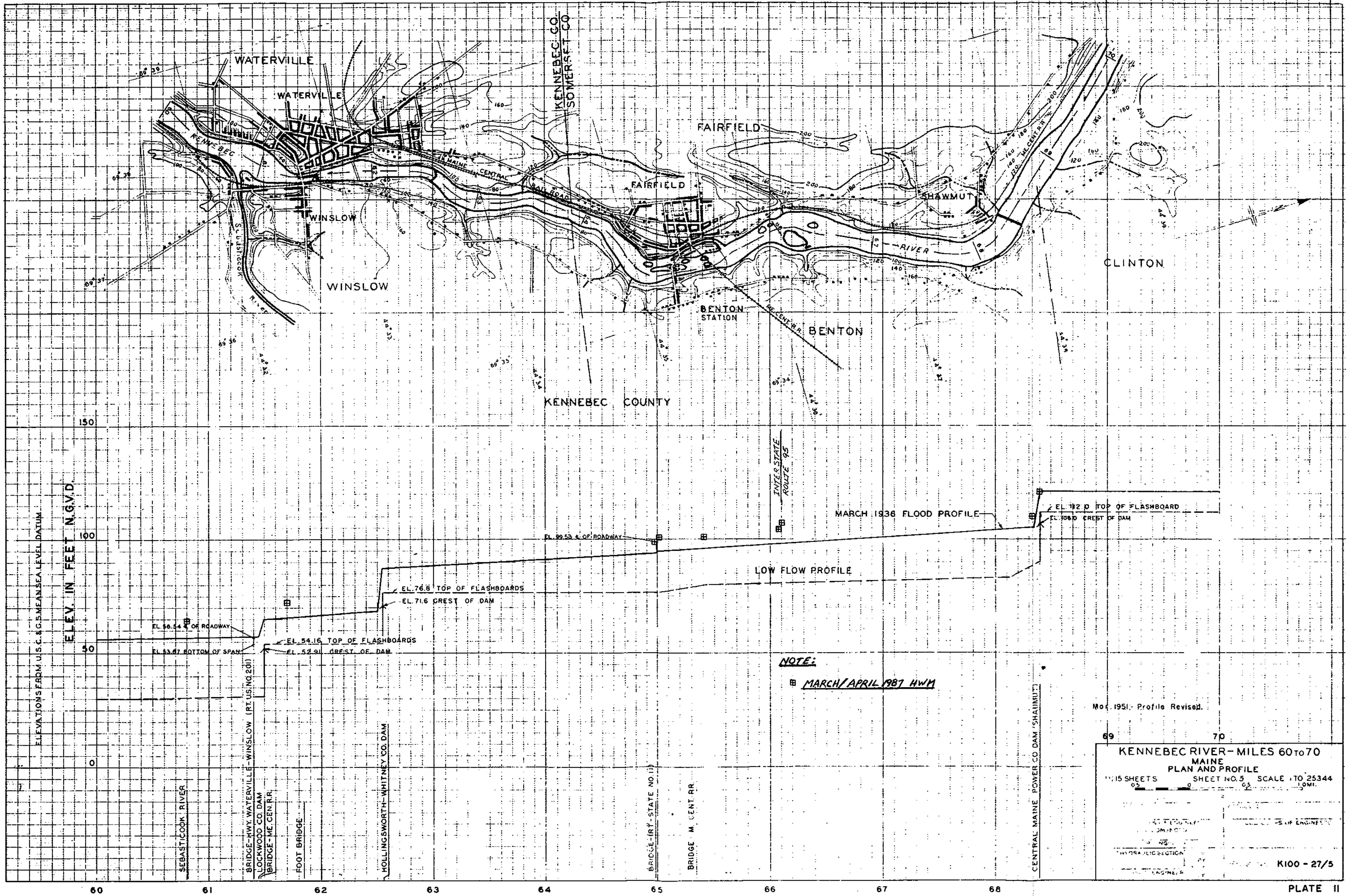
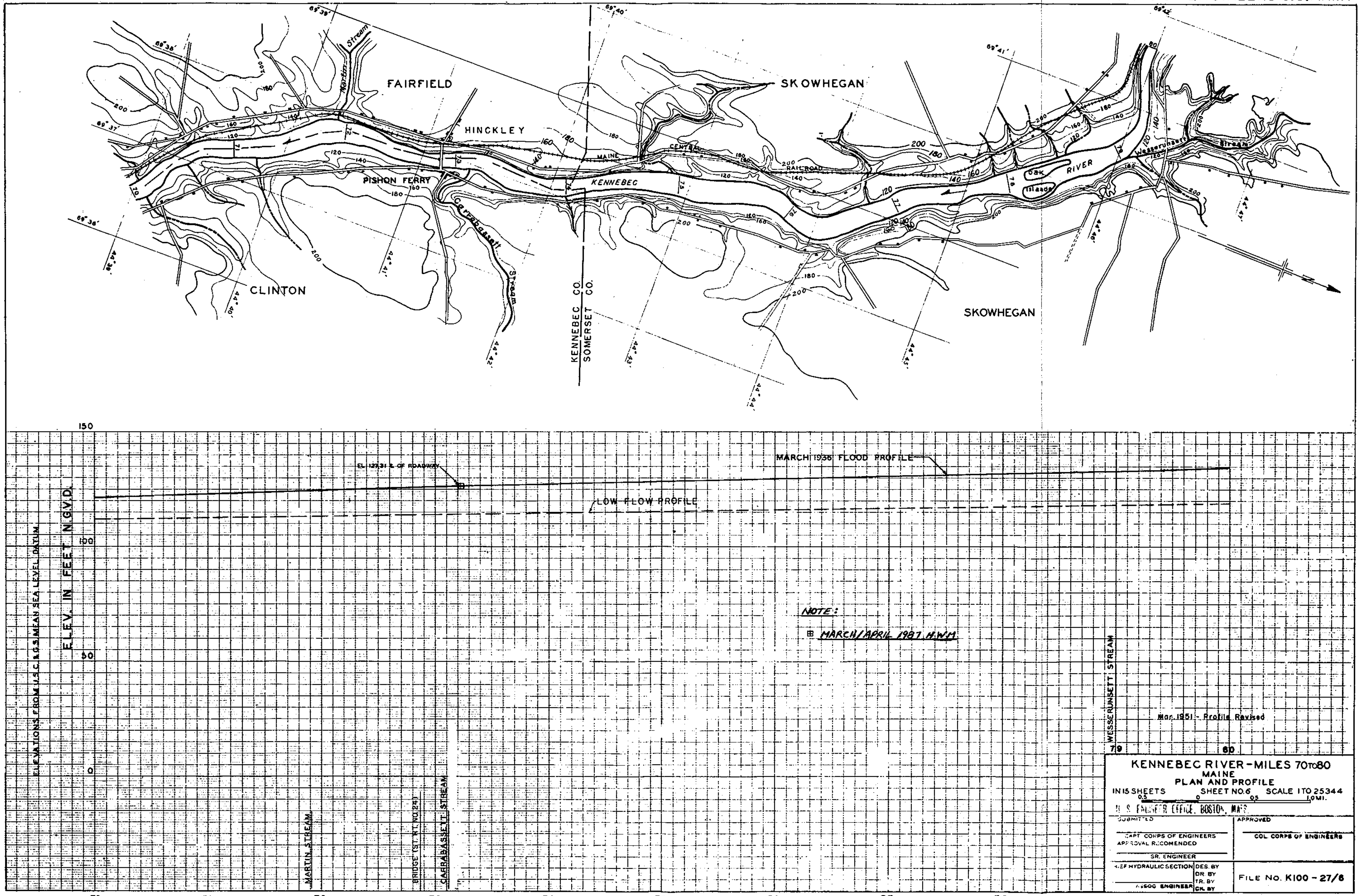


PLATE II


FAIRFIELD
HINCKLEY
SKOWHEGAN
PISHON FERRY
KENNEBEC
RIVER
MAINE CENTRAL RAILROAD
Oak Islands
Martin Stream
Carrabassett Stream
Wesserunsett Stream
CLINTON
KENNEBEC CO.
SOMERSET CO.
SKOWHEGAN
MARCH 1936 FLOOD PROFILE
EL. 127.31 ℄ OF ROADWAY
LOW FLOW PROFILE
NOTE:
⊞ MARCH/APRIL 1987 H.W.M.
ELEV. IN FEET N.G.V.D.
ELEVATIONS FROM U.S.C.&G.S. MEAN SEA LEVEL DATUM
MARTIN STREAM
BRIDGE (ST. RT. NO. 24)
CARRABASSETT STREAM
WESSERUNSETT STREAM
Mar. 1951 - Profile Revised
70
71
72
73
74
75
76
77
78
79
80
KENNEBEC RIVER - MILES 70 TO 80
MAINE
PLAN AND PROFILE
IN 15 SHEETS SHEET NO. 6 SCALE 1 TO 25344
U.S. ENGINEER OFFICE, BOSTON, MASS.
SUBMITTED
CAPT. CORPS OF ENGINEERS
APPROVAL RECOMENDED
SR. ENGINEER
APPROVED
COL. CORPS OF ENGINEERS
CHIEF HYDRAULIC SECTION
ASSOC. ENGINEER
DES. BY
DR. BY
TR. BY
CK. BY
FILE No. K100 - 27/6

CORPS OF ENGINEERS, U. S. ARMY

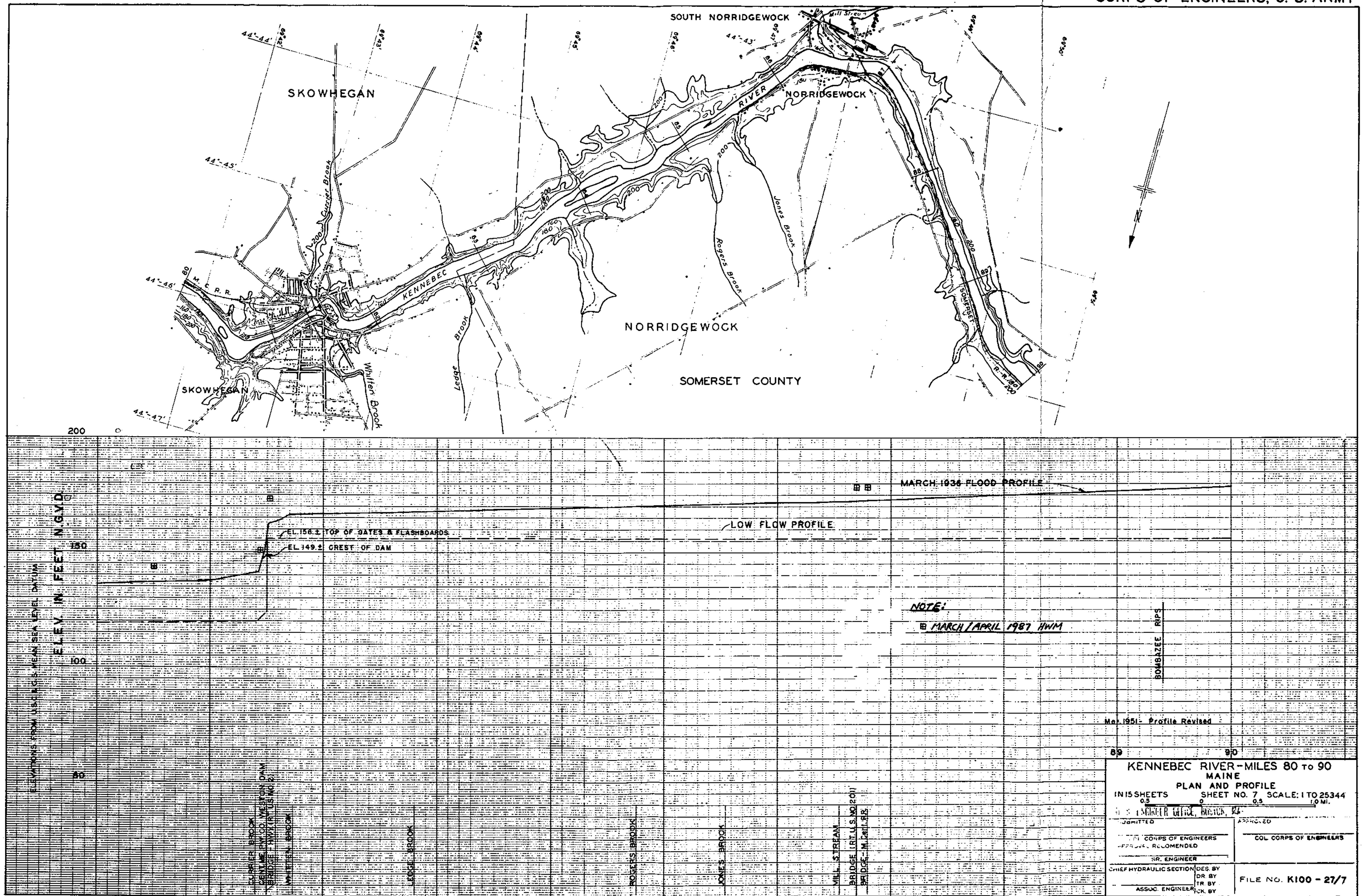
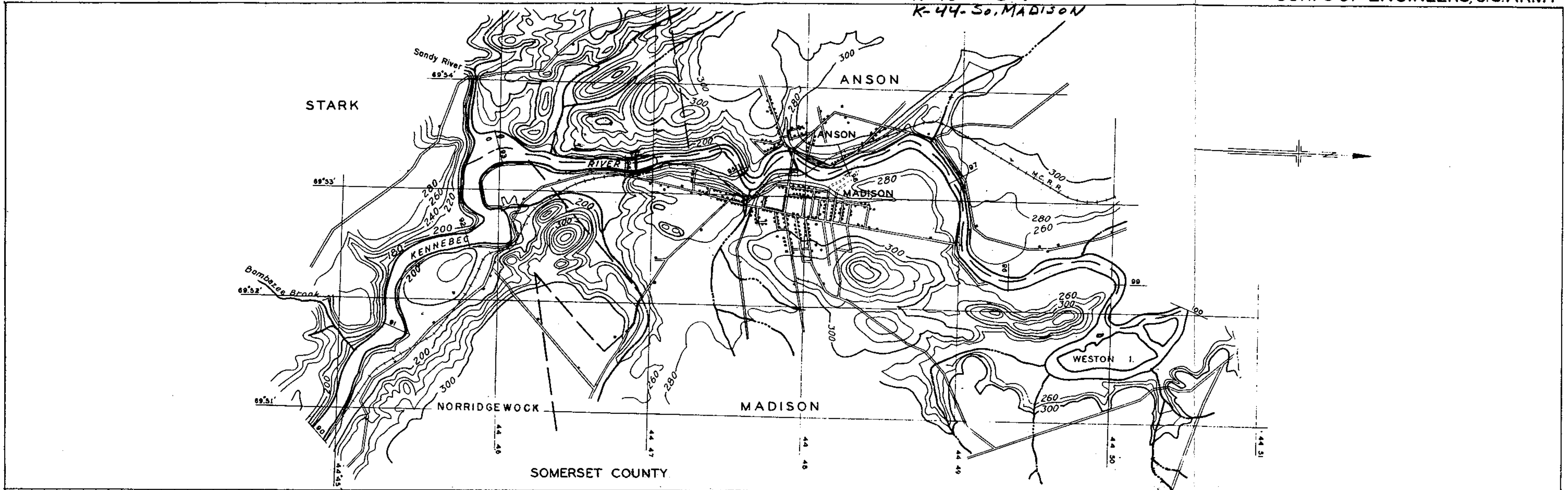
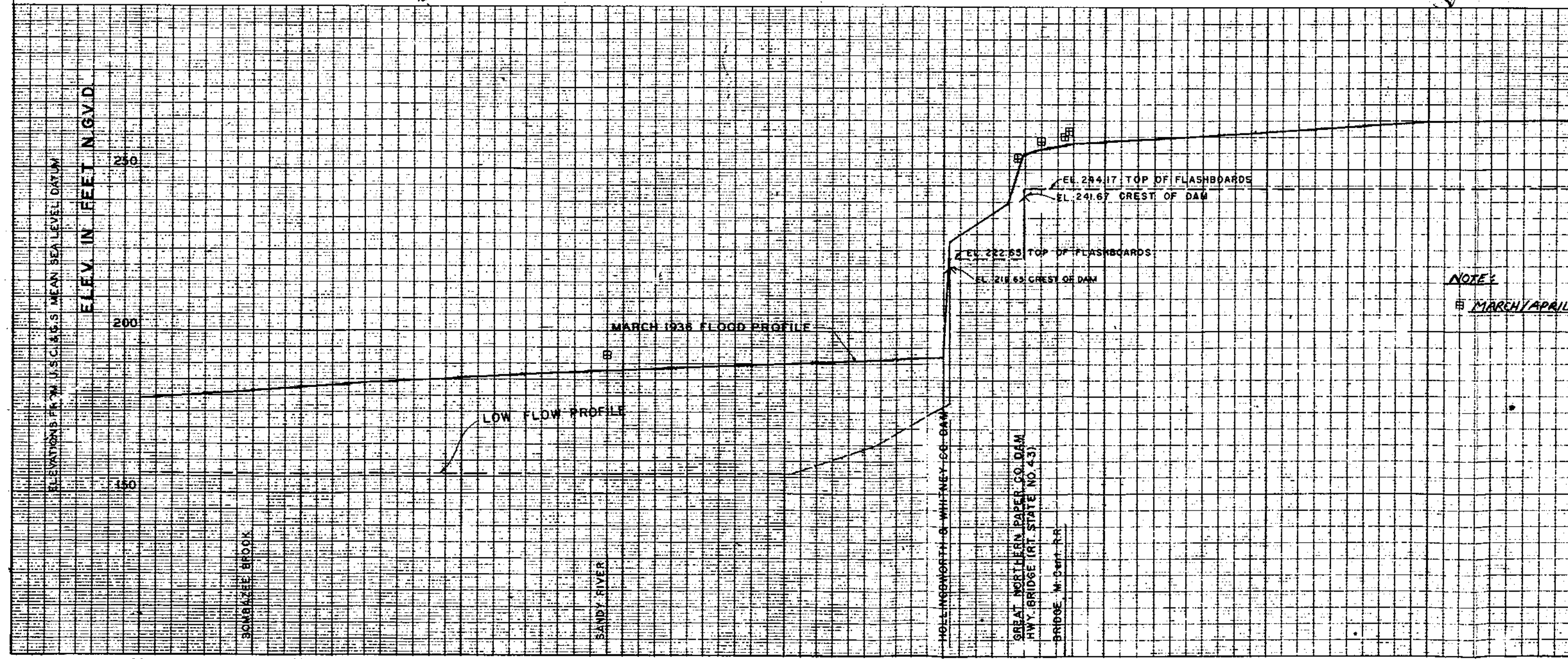


PLATE 13

K-42-MADISON
K-43-ANSON
K-44-So. MADISON





KENNEBEC RIVER-MILES 90 TO 100
MAINE
PLAN AND PROFILE

IN 15 SHEETS SHEET NO. 8 SCALE 1 TO 25344

U. S. ENGINEER OFFICE, BOSTON, MASS

SUBMITTED
CAPT. CORPS OF ENGINEERS
APPROVAL RECOMENDED
SR. ENGINEER
HYDRAULIC SECTION
ASSOC. ENGINEER
DES. BY
DR. BY
TR. BY
CK. BY

APPROVED
COL. CORPS OF ENGINEERS

FILE No. K100 - 27/8

PLATE 14

SECTION II

ENVIRONMENTAL CONSIDERATIONS

Kennebec River Basin
Reconnaissance Study

Environmental Considerations

September 1988

Terrence S. Fleming
Biologist

Table of Contents

A. Environmental

A.1. General Topography and Geology. The following description of the river basin is excerpted from the Kennebec River Basin Overview (NERBC, 1979).

> "The Kennebec River basin is located in west-central Maine, encompassing 5,870 square miles or one-fifth of the state. The third largest of the river basins lying wholly in New England, the Kennebec stretches from the mountainous U.S./Canada boundary 132 miles south to the rolling hills bordering Maine's coast."
>
> "The basin is predominantly hilly, ranging from mountainous terrain in the north to rolling coastal land in the south. One S-shaped curve interrupts the otherwise direct course of the Kennebec River as it flows through these land forms to Merrymeeting Bay."
>
> "The Moosehead Lake watershed, and its tributary, the Moose River form the headwaters of the Kennebec River. Flowing through Moosehead Lake's two outlets and through the Harris Dam impoundment, the main stem travels swiftly for 30 miles south through a narrow gorge, averaging a slope of 17 feet per mile. The White Mountain region also encompasses the entire watershed of the Dead River and the headwater areas of the Carrabasset and Sandy Rivers."
>
> "Further southward in the New England Uplands, elevations gradually decline to 500 feet. This area is characterized by gently sloping highlands rising above wide, flat valleys. The Kennebec River slows as it passes through this region, leveling to a slope of approximately six feet per mile. The river valley, usually bounded by steep wall, widens to include wetlands, broad flood plains, and islands. The Sandy, Carrabassett, and Sebasticook Rivers and Wesserunsett Stream flow into this reach of the river. The Sandy and Carrabassett Rivers originate in the higher elevations of the northwest and their slopes average 22 and 18 feet per mile respectively."
>
> "Moving further downstream to the Seaboard Lowlands, the elevation gradually drops to below 500 feet. This encompasses all the lower Kennebec River, skirting Cobbossee and Belgrade Lakes. The main stem corridor is deeply incised and backed by low, steep hills. At Augusta, 46 miles upstream of its mouth, the Kennebec becomes a tidal river."

A.2. Water Quality

The state of Maine Water Quality Classification for stretches of the Kennebec, Carrabassett River, Sandy River, Sebasticook River and Cobbosseecontee Stream are listed in Table A.2.1. State water quality standards are listed in Table A.2.2.

The waters of the Kennebec are designated Class B above Skowhegan dam and designated Class C from Skowhegan down to Merrymeeting Bay. The sections of the Carrabasset River above North Anson are desinated Class A and B, sections below North Anson are classified as Class C waters. The sections of the Sandy River above Farmington are designated Class A and B, the section below Farmington is classified as Class C waters. The Sebasticook River receives Class B and C ratings. Cobbosseecontee Stream also receives Class B and C ratings. In certain sections water quality standards may fall below the designations listed in Table A.3.1. Where appropriate, the relationship of these sections to the project area are discussed below in section B.2.

A.3. Biological Resources

The larger northern basin is mostly spruce-fir forests whereas the coastal uplands of the lower basin are more rural. Timber harvesting and seasonal recreation are the mainstay of the economy in the northern basin. The lower portion of the Kennebec River basin has some of the states best agricultural and dairy land.

Habitat types include forested uplands, forested wetlands, shrub-scrub wetlands, both persitent and non-persistent emergent wetlands, and open fields.

Bird species in the area include spotted sandpiper, great blue heron, mallard, black duck, common merganser, double-crested cormorant, herring gull, black-backed gull, belted kinfisher, common loon, American robin, song sparrow, yellow warbler, yellow-rumped warbler, wither wren, cedar waxwing, ruffed grouse, red-tailed hawk and kestrel.

Lists of vertebrate species likely to be found in the project area were compiled as part of the FERC licensing for the Williams Dam (CMP, 1986). Table A.3.1 presents a list of freshwater and anadromous fish in the Kennebec River Drainage. A list of mammals whose geographic range includes the project area, is presented in Table A.3.2. Table A.3.3 is a list of amphibians and reptiles whose range encompasses the project area.

TABLE A.2.1. WATER QUALITY CLASSIFICATION IN SELECTED REACHES OF THE KENNEBEC RIVER BASIN (MAINE DEP, 1987)

A. Kennebec River, main stem
   1. Moosehead Lake to Fall Brook (Solon)........................B
   2. Fall Brook (Solon) to Skowhegan.............................B
   3. Skowhegan to Shawmut Dam (Fairfield)........................C
   4. Shawmut Dam (Fairfield) to Curran Bridge (Augusta)..........C
   5. Curran Bridge (Augusta) to Abagadasset Point C
   6. Abagadasset Point to Merrymeeting Bay.......................C

B. Carrabassett River Drainage
   1. Carrabasset, Main stem
      a. Above confluence with west branch........................A
      b. West branch to North Anson...............................B
      c. North Anson to Kennebec..................................C
   2. Carrabasset River, tributaries
      a. Gilman stream (New Portland).............................C
      b. Harris brook (New Portland)..............................C
      c. Mill Stream (Anson)......................................C

C. Sandy River Drainage
   1. Sandy River, main stem
      a. Above Rte 142 (Phillips).................................A
      b. Phillips to Farmington...................................B
      c. Farmington to Kennebec River.............................C
   2. Sandy River, tributaries
      Lemon Stream (Starks) to Sandy River........................C
      Wilson Stream to Sandy River (Farmington)...................C
      Unnamed stream (New Sharon).................................C
      Unnamed stream (Farmington).................................C

D. Sebasticook River Drainage
   1. Sebasticook River, main stem
      a. Confluence of East and West branch to Pittsfield-Burnham border....C
      b. Pittsfield-Burnham to Clinton............................B
      c. Clinton to Benton Falls..................................C
      d. Benton Falls to CMP dam (Winslow)........................B
      e. CMP dam (Winslow) to Kenneber River......................C
   2. Sebasticook River, tributaries
      a. Farnham Brook (Pittsfield)...............................C

E. Cobboseecontee Stream
   1. Cobbossecontee Stream, main stem
      a. Above Dam ....B
      b. From Dam to Kennebec River (Gardiner)....................C

F. Kennebec River, minor tributaries
   1. Bond Brook (Augusta)..C
   2. Currier Brook (Skowhegan to Kennebec River).................C
   3. Mill Stream (Norridgewock to Kennebec River)................C
   4. Twomile Brook (Augusta).....................................C

TABLE A.2.2 STANDARDS FOR CLASSIFICATION OF SURFACE WATERS

<u>Class AA waters</u>. Class AA shall be the highest classification and shall be applied to waters which are outstanding natural resources and which should be preserved because of their ecological, social, scenic or recreational importance.

A. Class AA waters shall be of such quality that they are suitable for the designated uses of drinking water after disinfection, fishing, recreation in and on the water and navigation and as habitat for fish and other aquatic life. The habitat shall be characterized as free flowing and natural.
B. The aquatic life, dissolved oxygen and bacteria content of Class AA waters shall be as naturally occurs.
C. There shall be no direct discharge of pollutants to Class AA waters.

<u>Class A waters</u>. A. Class A water shall be of such quality that they are suitable for the designated uses of drinking water after disinfection; fishing; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation except as prohibited under Title 12, section 403; and navigation; and as habitat for fish and other aquatic life. The habitat shall be characterized as natural.
B. The dissovled oxygen content of Class A water shall be not less than 7 parts per million or 75% of saturation, whichever is higher. The aquatic life and bacteria content of Class A waters shall be as naturally occurs.
C. Direct discharges to these water licensed after January 1, 1986, shall be permitted only if, in addition to satistying all the requirements of this article, the discharged effluent will be equal to or better than the existing water quality of the receiving waters. Prior to issuing a discharge license, the board shall require the applicant to objectively demonstrate to the board's satisfaction that the discharge is necessary and that there are no other reasonable alternatives available. Discharges into waters of this classification which were licensed prior to January 1, 1986, shall be allowed to continue only until practical alternatives exist. There shall be no deposits of any material on the banks of these waters in any manner so that transfer of pollutants into the waters is likely.

Class B waters. A. Class B waters shall be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; recreation in and on the water; industrial process and cooling water; except as prohibited under Title 12, section 403, and navigation; and as habitat for fish and other aquatic life. The habitat shall be characterized as unimpaired.

B. The dissolved oxygen content of Class B waters shall be not less than 7 parts per million or 75% of saturation, whichever is higer, except that for the period from October 1st to May 14th, in order to ensure spawning and egg incubation of indigenous fish species, the 7-day mean dissolved oxygen concentratin shall not be less than 9.5 parts per million and the 1-day minimum shall not be less than 8.0 parts per million in identified fish spawning areas. Between May 15th and September 30th, the number of Escherichia coli bacteria of human origin in these waters may not exceed a geometric mean of 64 per 100 milliliters or an instantaneous level of 427 per 100 milliliters.

C. Discharges to Class B waters shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community

Class C waters. A. Class C waters shall be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation except as prohibited unter Title 12, section 403; and navigation; and as a habitat for fish and other aquatic life.

B. The dissolved oxygen content of Class C water shall be not less than 5 parts per million or 60% of saturation, whichever is higher, except that in identified salmonid spawning areas where water quality is sufficient to ensure spawning, egg incubation and survival of early life stages, that water quality sufficient for these purposes shall be maintained. Between May 15th and September 30th, the number of Escherichia coli bacteria of human origin in these waters may not exceed a geometric mean of 142 per 100 milliliters or an instantaneous level of 949 per 100 milliliters. The department shall promulgate rules governing the procedure for designation of spawning areas. Those rules shall include provision for periodic review of designated spawning areas and consultation with affected persons prior to designation of a stretch of water as a spawning area.

C. Discharges to Class C waters may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community.

TABLE A.3.1. SPECIES LIST OF FRESHWATER AND ANADROMOUS FISHES IN THE KENNEBEC RIVER DRAINAGE (CMP, 1986)

Sea Lamprey (Petromyzon marinus)	May - August
Shortnose sturgeon (Acipenser brevirostrum)	April - June
Atlantic sturgeon (Acipenser oxyrhynchus)	May - June
American eel (Anguilla rostrata)	December - January
Blueback Herring (Alosa aestivalis)	May - June
Alewife (Alosa pseudoharengus)	April - June
American shad (Alosa sapidisima)	May - June
Lake whitefish (Coregonus clupeaformis)	November - December
Round whitefish (Prosopium cylindraceus)	November - December
Rainbow trout (Salmo gairdneri)	April - May
Atlantic salmon (Salmo salar)	October - November
Brown trout (Salmo trutta)	October - November
Brook trout (Salvelinus fontinalis)	October - November
Lake trout (Salvelinus namaycush)	September - November
Rainbow smelt (Osmerus mordax)	April - May
Northern pike (Esox lucius)	
Chain pickerel (Esox niger)	April - May
Northern redbelly dace (Chrosomus eos)	June - August
Finescale dace (Chrosomus neogaeus)	June - August
Common Carp (Cyprinius carpio)	April - June
Lake chub (Couesius plumbius)	June - August
Eastern slippery minnow (Hybognathus regius)	
Golden shiner (Notemigonous crysoleucas)	May - July
Common shiner (Notropis cornutus)	April - June
Blacknose shiner (Notropis heterolepis)	April - June
Fathead minnow (Pimephales promelas)	April - June
Blacknose dace (Rhinichthys atratulus)	April - June
Longnose dace (Rhinichthys cataractae)	April - July
Radd (Scardinius erythrophthalmus)	
Creek chub (Semotilus atromaculatus)	April - May
Fallfish (Semotilus corporalis)	May - June
Pearl dace (Semotilus margarita)	April - May
Longnose sucker (Catostomus catostomus)	May
White sucker (Catostomus commersoni)	May
Brown bullhead (Ictalurus nebulosus)	May - July
Burbot (Lota lota)	December - March
Banded killifish (Fundulus diaphanus)	July - August
Mummichog (Fundulus heteroclitus)	June - August
Brook stickleback (Culaea inconstans)	May - June
Threespine stickleback (Gasterosteus aculeatus)	May - June
Ninespine stickelback (Pungitius pungitius)	May - July
White perch (Morone americana)	April - June
Striped bass (Morone saxatilis)	
Redbreast sunfish (Lepomis auritus)	July
Pumpkinseed (Lepomis gibbosus)	July - August
Smallmouth bass (Micropterus dolomieui)	June - July
Largemouth bass (Micropterus salmoides)	June
Black crappie (Promoxis nigromaculatus)	
Yellow perch (Perca cognatus)	April - May
Slimy sculpin (Cottus cognatus)	April - June

TABLE A.3.2. MAMMALS WHOSE GEOGRAPHIC RANGE OVERLAPS WITH THE PROJECT AREA (CMP, 1986)

Masked shrew (Sorex cinerus)
Water shrew (Sorex palustris)
Long-tailed shrew (Sorex fumeus)
Pygmy shrew (Sorex hoyi)
Short-tailed shrew (Blarina brevicauda)
Hairy-tailed mole (Parascalops breweri)
Star-nosed mole (Condylura cristata)
Little brown myotis (Myotis lucifugus)
Keen's myotis (Myotis keenii)
Silver-haired bat (Lasionycteris noctivagans)
Big brown bat (Eptesicus fuscus)
Red bat (Lasiurus borealis)
Hoary bat (Lasiurus cinereus)
Snowshoe hare (Lepus americanus)
Eastern chipmunk (Tamias striatus)
Woodchuck (Marmota monax)
Gray squirrel (Sciurus carolinensis)
Red squirrel (Tamiasciurus hudsonicus)
Northern flying squirrel (Glaucomys sabrinus)
Beaver (Castor canadensis)
Deer mouse (Peromyscus maniculatus)
Southern red-backed vole (Clethrionomys gapperi)
Meadow vole (Microtus pennsylvanicus)
Muskrat (Ondatra zibethicus)
Southern bog lemming (Synaptomys cooperi)
Meadow jumping mouse (Zapos hudsonicus)
Woodland jumping mouse (Napaeozapus insignis)
Porcupine (Erethizon dorsatum)
Coyote (Canis latrans)
Red fox (Vulpes vulpes)
Black bear (Ursus americanus)
Raccoon (Procyon lotor)
Marten (Martes americana)
Ermine (Mustela erminea)
Long-tailed weasel (Mustela frenata)
Mink (Mustela vision)
Striped skunk (Mephitis mephitis)
River otter (Lutra canadensis)
Bobcat (Felis rufus)
White-tailed deer (Odocoileus virginianus)
Moose (Alces alces)

TABLE A.3.3. AMPHIBIANS AND REPTILES WHOSE RANGE OVERLAPS WITH THE PROJECT AREA (CMP, 1986)

Jefferson salamander (Ambystoma jeffersonianum)	
Blue-spotted salamander (Ambystoma laterace)	*S
Spotted salamander (Abmystoma maculatum)	
Red-spotted newt (Notophthalmus v. viridescens)	
Northern dusky salamander (Desmognathus f. fuscus)	
Redback salamander (Plethodon cinereus)	
Four-toed salamander (Hemidactylium scutatum)	*ST
Northern spring salamander (Gyrinophilus p. porphyriticus)	
Northern two-lined salamander (Eurycea b. bislineata)	
Eastern American toad (Bufo a. americanus)	
Northern spring peeper (Hyla c. crucifer)	
Green frog (Rana clamitans melanuta)	
Mink frog (Rana septentrionales)	*S
Wood frog (Rana sylvatica)	
Northern leopard frog (Rana pipiens)	
Pickerel frog (Rana palustris)	
Common snapping turtle (Chelydra s. serpentina)	
Spotted turtle (Clemmys guttata)	*ST
Wood turtle (Clemmys insculpata)	*S
Painted turtle (Chrysemys picta)	
Northern water snake (Nerodia s. sipedon)	
Northern redbelly snake (Storeria o occipitomaculata)	
Eastern garter snake (Thamnophis s sirtalis)	
Northern ribbon snake (Thamnophis sauritus septentrionales)	
Northern ringneck snake (Diadophis punctatus edwardsi)	
Northern black racer (Coluber c. constrictor)	
Eastern smooth green snake (Opheodrys v. vernalis)	
Eastern milk snake (Lampropeltis t. triangulum)	

New England Natural Heritage Program of the Nature Conservancy (1983) lists: (S) = apparently secure in state, "watch" status may apply; (ST) = state threatened.

A.4. Threatened and Endangered Species

Bald Eagles (<u>Haliaeetus</u> <u>leucoephalus</u>) nest and overwinter at a number of sites along the Kennebec, especially the lower sections of the river. Impacts to Bald Eagles are of particular concern in the Augusta area and south (Augusta, Hallowell, Gardiner, Randolph) and around the confluence of the Sebasticook and Kennebec rivers (Winslow and Waterville)

Shortnose sturgeon (<u>Acipenser</u> <u>brevirostrum</u>) which inhabit the Kennebec River south of Augusta are Federally listed as an endangered species. The Shortnose sturgeon is an anadromous fish. The high flows and narrow channel provide spawning habitat for the adults which spawn in the spring (April - June). A section 7 Endangered Specis consultation would be required for parts of the project below Edwards Dam in Augusta which might involve activity in the water.

Piping plover (<u>Charadrius</u> <u>melodus</u>) nest and feed on coastal beaches. The towns of Gardiner and Randolph represent the southern extreme of the project and therefore would not impact piping plover habitat.

The small Whorled Pogonia (<u>Isotria</u> <u>medeoloides</u>) is an endangered plant species which occurs in Kennebec County. This plant favors the acidic soil of dry woods and is not likely to be found near the river.

A.5. Archaeological Resources

[THIS SECTION TO BE PREPARED BY STAFF ARCHAEOLOGIST]

B.1. General Impacts

B.1.a. Dikes and Walls. The construction of 23,000 feet of dikes and/or walls along the Kennebec River and tributaries could displace up to 52.8 acres (2,300,000 square feet) of upland, riparian and river habitat. This rough estimate was calculated by multiplying the linear footage of protection by a 100′ impact width of the dikes. In terms of the amount of habitat that is permanently displaced, walls would have much less of an impact than dikes.

The construction impacts associated with building new walls would extend beyond width of the wall stem. The base of the standard T-wall would be roughly equivalent to the height of the proposed wall. This area would have to be excavated, during construction. In some cases the riverside of the wall would be stabilized with riprap. Depending on the slope and alignment of the wall, riprap may extend into the river at certain sites.

The economic justification for walls would have to be weighed against the value of the resource to be protected. The quality and amount of habitat displaced obviously varies with each location and site specific environmental considerations are discussed in section B.2. Nevertheless, some general impacts/concerns are common to all areas.

1. <u>Construction impacts</u>. Construction activities could result in temporary disturbances to fish and wildlife populations. Fish would be impacted by siltation associated with construction. Impacts to fish populations can be minimized by keeping structures and equipment out of the water where possible and by employing proper sediment control measures. Construction activity may also be subject to seasonal restrictions, based on the evaluation of impacts in future project studies and coordination with State and Federal agencies.

Wildlife utilizing adjacent habitat could be displaced during disruptive construction activities. Depending on the season and length of the construction period. Displacement may result in direct mortality due to nest abandonment or dispersal related losses (predation, competition, road kill, etc). Although disturbance cannot be eliminated, mortality associated with nest failure can be reduced by scheduling construction activities for the late summer and fall months.

2. <u>Loss of wildlife habitat</u>. The riparian zone is valued as prime wildlife habitat. Construction of dikes and/or walls would eliminate shallow-water rearing habitat, overhanging bank cover, and wetland habitat. The river bank which provides valuable nursery habitat and refuge for juvenile fish, would be replaced by wall or riprap. The presence of dikes and/or walls would also restrict access to bank habitat for mammals.

Potential changes in the flow conditions or substrate characteristics could also affect vegetation in the vicinity of the dike resulting in a shift in toward plant species with lower wildlife value. Impacts could extend beyond the footprint of the dike/wall if they prevent seasonal high flows from recharging adjacent wetland or riparian areas.

3. Public access and aesthetics. The State encourages use of the river for fishing and recreation. Maintaining and enhancing the aesthetic quality should be an important consideration in developing plans for the area. Many of the areas where structural solutions are being considered provide public access for fishing. Where possible, access to such areas should be maintained.

Recent Corps publications provide guidelines for incorporating environmental features into the design of flood control projects (Nunnally and Shields, 1985; Hynson et al., 1985)

B.1.b. Dry-Bed Flood Control Dams.

Both the Sandy and Carrabasset Rivers are being investigated as sites for a potential flood control dam. Individually these dams would reduce downstream flooding by 15 to 20%, together they would reduce flooding downstream by 30%.

The earth filled dams would consist of an impervious clay core, a gravel layer, and an outer layer of stone bedding. Plans would be designed to accomodate 6 inches of runoff from the controlled basin with spillways to deal with overflow.

Under normal operating conditions (no-flood) the natural flow of the river would not be affected by the dam. During a flood event the gates would be closed and water allowed to pool behind the gate. The size of the pool would depend on the magnitude of the flood event. The footprints of the resevoirs at full capacity were estimated by tracing contour lines corresponding to the storage capacity elevations on the USGS maps (See Section B.3 for acreage and outline of impoundments). After the flood, water would be metered out, the rate determined by the downstream channel capacity and other hydrologic conditions.

The major issues/concerns can be divided between construction and operation impacts.

1. Impacts associated with construction. The footprint of the dam would displace some habitat. This area would be stripped of vegetation prior to construction to provide a stable base for the dam. Prior to construction an area upstream of the dam would be selectively cleared of large shrubs and trees that would not survive periodic submergence. This minimizes the maintenance problem of trees floating and blocking the outlet gates. Clearing would reduce the wildlife value of riparian and upland habitat and could enhance erosion upstream of the dam. The land downstream of the dike and the spillways would not be cleared.

2. Impacts associated with normal operation of the dam. The character of the river upstream and downstream of the dam could be altered by its operation. Potential impacts to the river bank include enhanced erosion associated with clearing and slumping of saturated soils along the margin of an impoundment. Sediment characteristics upstream and downstream of the river may also be affected by operation of the dam. A flood event would carry suspended material toward the dam which would likely be deposited at the base of the dam and along the banks of the river near the dam.

Any reduction in the downstream transport of material, either under no-flood conditions, during impoundment, or during post-flood discharge, could alter sediment substrate characteristics of the river bed.

Changes in substrate characteristics in the river bed and river bank could effect wildlife and vegetation. Vegetation along the river would also change in response to fluctuating water levels in the impoundment area. The existing streamside wetlands and riparian forest would be replaced by assemblages of species tolerant of irregular flooding. Maintenance of this area in an early successional stage would reduce habitat value of the riparian zone.

Impacts to wildlife would not be limited to the acreage of habitat cleared or flooded. Entire populations of animals in the basins could be affected by decreased foraging area and by the loss of cover along seasonal migration routes traditionally provided by riparian corridors.

Annual flooding of the impoundment area could also impact wildlife production levels. Rising water elevations during a Spring flood could drown animals which breed in the lowland areas. Animals nesting on the ground or in the shrub layer would be particularly vulnerable to nest or brood loss due to inundation. Water stress may result in a loss of canopy cover indirectly affecting arboreal species.

Fishery resources could also be negatively affected by the operation of the flood control reservoirs. Loss of cover and shade associated with the alteration and loss of streamside vegetation may result in decreased habitat quality. Substrate suitability for spawning and food production may also be reduced as a result of sediment deposition behind the dam. Increased sediment levels can adversely affect fish eggs, fish gills, and can reduce habitat quality by filling in pools and smothering productive riffles. Increased water temperatures associated with reduced cover could impact cold water species, such as trout and salmon.

Impacts to aquatic habitat downstream of the impoundments could also be expected. Substrate suitability for spawning and food production may be reduced if gravel recruitment is interrupted by the dams. Water turbidity and sediment levels may increase if fine material accumulating behind the dams during impoundment is transported downstream with the release of stored flood waters.

Fishery habitat could also be affected by instream flow changes on both sides of the dam. Free flowing riverine habitat would be converted to slow moving lake habitat during periods of impoundment. Natural flow levels below the dam would be decreased during periods of storage and increased when stored water is released. Fluctuating water levels can cause strandings of fish and fish eggs.

The dams could affect the seasonal movement patterns of existing resident fish as well as the migration of anadromous species slated for restoration (Atlantic salmon, shad and alewives) in both the Sandy and Carrabassett River basins.

The effects of fluctuating water levels on fish and wildlife which breed in the spring is an issue that should be considered. To reduce impacts to fish and wildlife, the time that water is kept behind the impoundment should be minimized.

B.2. Site specific consideration of the impact of dikes and walls.

B.2.a. Madison. The plans for Madison include increasing the height of existing walls on both sides of Route 148 and adding to an existing dike (earth covered sheet pile wall) along a lowland area between the railroad bridge and the paper mill.

The earth covered dike is maintained as a grassy picnic area. There is a 10- to 12-foot wide band of shrubs along the river including: staghorn sumac, speckled alder, gray birch, poison ivy, ash, nightshade, raspberry, goldenrod, burdock and milkweed. This strip of vegetation provides limited cover for small birds and mammals and aquatic animals along the edge of the river.

Other than temporary noise and construction impacts no environmental impacts are anticipated with increasing the height of existing walls. Construction of the 200 feet long dike would displace approximately 20,000 square feet of vegetated habitat.

B.2.b. Anson. The town of Anson is directly across the river from Madison. The proposed plan involves increasing the height of the existing concrete retaining wall along Route 201A south of Route 148. There is a narrow band of grass with several ornamental spruce trees between the highway and the river that could be affected by raising the wall. There would be no habitat loss associated with this alternative.

B.2.c. Norridgewock. No structural solution is planned for Norridgewock.

B.2.d. Skowhegan. A small dike (1,000 to 1,200 feet long) is proposed to alleviate flooding along Elm Street and Pleasant Street in Skowhegan. The dike would eliminate 100,000 to 120,000 square feet of vegetated habitat. The dike would be located in a vacant residential lot that is bordered by a small stream. The lot is overgrown with bracken fern, goldenrod, milkweed, wild carrot and raspberry. The wetland border along the river's edge contains cattails, sedges, pickerel weed, red-osier dogwood, and Joe-pye-weed. The stream channel has dense riparian cover with sugar maple, ash, willow, box elder, blackcherry, jewelweed, nightshade, Virginia creeper and buttercup.

B.2.e. Faifield. The proposed structural solution to prevent flooding in the area involves approximately 3,000 feet of dikes and/or walls along the River in the vicinity of the Upper Main street. Construction of dikes or walls would result in the loss of approximately 300,000 feet of streamside habitat.

There is a 10 to 40-foot wide band of riparian vegetation that runs along the entire 3,000 foot reach. The riparian zone varies from 10 to 40 feet wide. The upper (upstream) segment contains dense woody vegetation that hangs out over the river, providing excellent fish and wildlife habitat conditions. Tree species here include willow, silver maple, red oak, elm, ash and box elder. Understory plants are primarily red-osier dogwood, japanese knotweed, Virginia creeper, grape, raspberry and staghorn sumac. Herbaceous species include milkweed, grape, raspberry, Joe-Pye-weed, goldenrod, ostrich fern, sensitive fern, jewelweed, nettle, Virginia Creeper, burdock, and nightshade. The lower (downstream) portion of the study area contains many of the same species (quaking aspen is also present) but the understory has been cleared and overhanging vegetation is absent.

Due to the close proximity of structures to the river, the dike/wall would be very close to the river and possiblly encroach in the water in some places. The primary fishery in this reach is for smallmouth bass and brown trout. The area is stocked with brown trout by the Department of Inland Fisheries and Wildlife. Potential impacts of the project to the reproduction and habitat of these species would have to be considered for activities occuring in the river.

Islands in the Fairfield vicinity offer good waterfowl breeding habitat. They also receive seasonal use by waterfowl, cormorants, gulls, and other migratory birds. Noise impacts to breeding waterfowl should be considered in further studies.

B.2.f. Winslow. The town of Winslow is located at the confluence of the Sebasticook and Kennebec Rivers. Central Maine Power operates a Hydroelectric plant upstream of the Kennebec in the town of Waterville and Scott Paper operates a dam upstream of the Sebasticook. Construction of a 2,800-foot dike or wall on the bank of the river, parallel to Lithgow Street to protect the area below the Sebasticook has the potential to displace 280,000 square feet of riparian habitat.

The site now contains sparse tree cover of species such as ash, willow, box elder, and sugar maple, The understory consists of pioneering plants that have invaded the disturbed residential lots. Species include burdock, ragweed, thistle, goldenrod, butter and eggs, wild carrot, nightshade, Virginia creeper, and wild rose. Red-osier dogwood, Joe-Pye-weed, and jewelweed are found on the river banks.

There is a popular fishery for brown trout and smallmouth bass along the bank at Winslow. Impacts to fish species and ways to maintain public access are issues which would need to be considered in further studies.

Black duck are known to congregate at the confluence of the two rivers. Noise impacts to black duck populations should also be considered in further studies. Bald eagles also frequent the area. Construction of the dikes would represent a temporary disturbance to eagles and could result in the loss of perch trees. Such impacts would be addressed in an endangered species consultation.

B.2.g. Waterville. The construction of a 2000' to 3000' of dike and/or wall along the west side of the river, just downstream of the Central Maine Power Dam would result in the loss of riparian habitat. The dike/wall would be even in height with the existing wall and most likely would tie in to high ground in an area of forested wetland. Construction of the dike has the potential to impact 200,000 to 300,000 square feet of riparian habitat. Much of the dike/wall could be located on ground that has already been raised and armored for flood protection, reducing the amount of habitat that is impacted. This land is currently used as a parking lot.

The forested wetland includes species such as red and silver maple, box elder, ash, willow, red-osier dogwood, arrowwood, Joe-Pye-weed, and jewelweed. The combination of forested wetland and a small island near the shore make the area good wildlife habitat. The area provides nursery habitat for brown trout which are regularly stocked. The existing popularity of the area for angling may further increase with expected changes to the dam that would direct more flow towards the west bank of the river. Public access to this area should be maintained.

B.2.h. Augusta. To alleviate flooding in the Augusta area approximately 3,000 feet of dikes and/or walls are proposed for stretches along both sides of the River, from Memorial bridge to Bond Brook on the west side and from Memorial bridge south to town Hall on the East side (See map for details).

The western shore is heavily developed and provides limited habitat value for wildlife. The river banks are for the most part armored with heavy riprap. Patches of shrubby box elder, willow, and silver maple occur in several places along the bank. There is a stand of riparian vegetation about 20 feet wide at the mouth of Bond Brook that extends downstream about 200 feet. It is comprised of elm, box elder, willow, grape. purple loosetrife and japanese knotweed. There is a narrow band of vegetation on the east bank of the river in the vicinity of the old town hall. Species here include willow, black locust, box elder, grape, raspberry, goldenrod and japanese knotweed.

Many valuable fish species spawn in the section of the river including smelt (April - May), shad (May - June), possibly striped bass (April - June). Bond Brook provides important spawning and rearing habitat for brown trout, brook trout and Atlantic salmon which spawn during the months of October and November. The brook also provides a coldwater refuge for these salmonids when temperatures in the Kennebec become stressful. Shortnose sturgeon also spawn in the area in April through June.

There is a recreational fishery for white perch, striped bass, Atlantic salmon, shad, brown trout, and smelt. Spring fishing is particularly intense on the west bank of the river near Bond Brook and along Front street. Public access to these areas should be maintained.

To avoid impacts to fish species, structures should be kept out of the water as much as possible. Any construction activities in the water would be subject to a seasonal construction window (No activity between the months of April to November). An endangered species consultation would be required to determine effects of this portion of the project on the shortnosed sturgeon.

Eagles have been sited in the general area and the intertidal area north of Memorial bridge is important area for black duck and other waterfowl. Construction and noise impacts to these species should be addressed in further studies.

B.2.i. Hallowell. The town of Hallowell is located downstream from Augusta on the west side of the Kennebec River. The construction of 3000 to 4000 feet of dikes and/or walls is proposed as a structural solution to prevent flooding of the Central Business District in Hallowell. Construction of the dikes would displace an area of approximately 300,000 to 400,000 square feet. Floodproofing is also being considered in the area. The feasability of floodproofing is unknown with the Historic nature of the buildings along Water Street.

Habitat value in the area has been reduced by existing development and previous filling along the river. Much of the site is covered by parking spaces and grassed parkland. Vegetation along the river bank includes willow, box elder, knotweed, red-osier dogwood, elm, ash, St. John's Wort, yarrow, galium, clover, nightshade, wild rose, grape, and raspberry.

This portion of the river provides habitat for numerous species of birds. The intertidal flats attract significant shorebird populations. There are small patches of shrubs and trees that provide nesting habitat for passerine birds. There is one historic and one active eagles nest on the undeveloped east side of the river.

Smelt spawn in the mainstem of the river from April to May and there is an active winter smelt fishery in the area. Vaugh Brook, a small tributary which feeds into the Kennebec, provides spawning habitat for smelt and a refuge for juvenile salmon. Structures proposed for the area would not impact Vaughn Brook.

B.2.j. Gardiner. Gardiner is located downstream from Hallowell on the west side of the river. The Cobbosseecontee Stream flows through the city before joining the Kennebec. A small dike (app. 2500 feet long) is proposed as a structural solution to alleviate flooding of the commercial downtown area. This would impact 250,000 square feet of area. The dike would run along an existing railroad bed, cutting across the Cobbosseeconte Stream. Some portion of the Cobbosseconte would need to be channeled through a pressure conduit to prevent backflooding from the Kennebec.

Most of the shoreline in this area consists of riprap and bulkhead with sparse vegetation. There is about 1000 feet of natural shoreline at the north end of the study site. Vegetation here is limited to a narrow band of riparian vegetation between the river and the railroad tracks to the west. Plant species include ash, box elder, sugar maple, red-osier dogwood, speckled alder, honeysuckle, Joe-Pye-weed, and purple loosestrife.

This reach of the Kennebec is noted for striped bass fishery. People fish for striped bass and striped perch from the banks of the Kennebec and Cobbosseecontee rivers. The Cobbosseecontee provides nursery habitat for Atlantic salmon, brown trout, shad, smelt and alewive. The Cobbosseconte Stream drainage has been designated in the anadromous fishery plan for early restoration of alewives.

The dike and pressure conduit could have significant environmental impacts on the Cobbosseecontee, that would have to be addressed in further studies.

B.2.k. Randolph. The town of Randolph is located on the east side of the river across from Gardiner. The Togus stream empties in the Kennebec in the northern part of Randolph. The Togus stream meets class B water quality standards has a natural population of Atlantic Salmon and alewife. The marsh at the mouth of the Togus stream provides habitat for various waterfowl.

Low elevations along the river make this area particularly susceptible to flooding. A long linear section of dike or wall along the river would be needed to protect the downtown area from flooding. Habitat value in the central part of town is limited to several small stands of trees, primarily box elder, ash and black locust. There are several high quality shrub-scrub wetlands and emergent wetlands along the river that would be adversely affected by the construction of dikes and or walls.

Floodproofing is the most likely solution to the towns flooding problem. This could be accomplished without adverse environmental impacts.

B.2.l. Hartland. Hartland is located on the Sebasticook. No structural solution is proposed for the town of Hartland.

B.2.m. Pittsfield. The City of Pittsfield is located on the Sebasticook downriver from Hartland. The construction of approximately 2000' of dike or wall along a shallow section of the river would protect the area between Detroit street and Dobson street ending at Hunnewell street from flooding. The dike or wall would displace approximately 200,000 square feet of riparian habitat. Flooding around Mill Pond could be alleviated by increasing the size of the outgoing culvert.

Bordering the river along the entire reach is a 10- to 50-foot wide wooded riparian zone. Overstory species here include red maple, ash, box elder, silvermaple, red oad, and choke cherry. There is a well developed understory, very dense in places, consisting of arrowwood, silky and red-osier dogwood, alder-buckthorn, honeysuckel, and wild rose. Ground cover includes wood sorrel, bayberry, galium, gooseberry, Birginia creeper, roual fern, raspberry and sensitive fern.

The Sebasticook River plays a role in the State's anadromous fish restoration plans for the Kennebec River Basin. Alewives and shad are currently being stocked in the Sebasticook Basin. The river offers primarily a warm-water fishery for bass, black crappie, and perch. It is seasonally important for cold-water species like brown and brook trout.

B.2.n. Farmington. The town of Farmington is located on the Sandy River. A dike and/or wall 1200 to 1500 feet long is proposed as a structural solution to flooding in the area. This area was not surveyed for environmental resources. It is assumed that placement of structures in the area has the potential to impact 120,000 to 150,000 square feet of habitat.

B.3. Site Specific Considerations of Dry-Bed Flood Control Dams

B.3.1. Carrabasset River. The Carrabassett subbasin has a drainage area of approximately 400 square miles. All 45 miles of the Carrabasset River have been included in the Nationwide Rivers Inventory for possible designation as a Wild and Scenic River. Its designation as a Category "B" river in the Maine Rivers Study denotes significant resource value.

The waters of the Carrabasset River are designated as Class A above the West Branch, Class B from the west Branch to North Anson and Class C from North Anson to the Kennebec. Gilman Stream and Sandy stream are both designated as Class C waters.

A dry-bed flood control dam on the Carrabasset River approximately 5 miles northwest of the town of North Anson is proposed as one option to decrease flooding. A suitable area for flood storage is formed by the lower slopes of New Portland Hill on the south, Black Hill, Goodrich Hill, Hacket Hill, Chandler Hill and Hutchins Hill on the east; Gilman Pond Mountain and Millay Hill on the west; and Peaked Hill and Howard Hill on the north. Numerous small brooks (Clark, Sucker, Schoolhouse, Bear, Adler, Pease, and Healy Brooks) direct runoff from these highland areas which pours into Sandy and Gilman Streams. The Sandy stream runs north-south through this drainage area enters Gilman Pond and becomes the Gilman Stream before entering the Carrabasset near the town of East New Portland.

The footprint of the 65 foot high dam would be 2000 feet long x 600 feet wide displacing approximately 36.7 acres (1,600,000 square feet) of habitat. Approximately 81 acres of land near the dam that would be selectively cleared resulting in a significant impact to high quality riparian habitat.

The outline of the impoundment area at full storage capacity corresponds to the 420 foot contour elevation and is shown in figure B.3.a. This area encompasses approximately 7190 acres of land, including approximately 5 miles of the Carrabasset River, 2 miles of Hutchings Brook, 1.5 miles of Meadow Brook, 2 miles of Clark brook, 4.5 miles of Gilman stream, all 790 acres of Gilman Pond, 5 miles of Alder Brook, and 8 miles of Sandy stream. The town of New Portland is in the impoundment area and would have to be relocated.

The primary cover type in the impoundment area is mixed deciduous/coniferous forest with species such as white pine, red oak, eastern hemlock, various maples, American larch, black cherry and the American beech. Soil Conservation Service surveys indicate that the impoundment area does not include significant amounts of prime agricultural or timber lands (SCS, 1988). The Carabassett River channel is braided in places and the islands support mature stands of riparian hardwood forests with box elder, red maple, white, yellow, and gray birch, choke cherry, balsam poplar, and red-osier dogwood.

The extensive wetlands known as collectively as Lexington Flats would be affected by the flooding associated with impoundment. South of Gilman Pond the wetlands appear to be primarily red maple swamps. There are extensive areas of emergent wetlands, most vegetated with sedges, associated with the northern reaches of the pond. Moving north into the Sandy Stream and Alder Brook drainages, there are hundreds of acres of interspersed forested, shrub-scrub, and emergent wetlands. The forested wetlands are hummocky and include red maple, northern white cedar, black spruce, black ash, hemlock, and balsam fir. The shrub-scrub wetlands are mostly dense thickets of speckled alder and gray birch. Emergent wetlands contain nostly sedges, many with standing snags. Other plants observed among these three wetland types include: spirea, sweet gale, hobblebush, raspberry, lambkill, alder buckthorn, elderberry, choke cherry, galium, false solomon's seal, sedge spp. marsh cinquefoil, soft rush, blue flag, and sensitive, cinnamon, royal and ostrich fern.

The Carrabassett River Basin contains high quality habitat for a variety of wildlife. The extensive wetland areas in the Gilman Pond drainage are good producers of waterfowl such as wood duck, black duck, and possibly merganser and goldeneye. The entire basin provides summer habitat for big game species such as black bear, moose, and white-tailed deer. There are deer wintering areas in the upper reaches of Sandy Stream and Alder Brook, Gilman Pond hosts nesting common loons and is also a Canada goose release site.

Aquatic habitat conditions in the Carrabassett River are excellent with extensive gravel riffles and side channels. Recreationally important fish species in the Basin include: smallmouth bass, brook trout, brown trout, pickerel, yellow perch, sunfish, and brown bullhead. Atlantic salmon are also a species of concern within the Carrabassett Basin. State and Federal fishery management agencies have developed plans to eventually restore Atlantic salmon to their historic range within the Kennebec Basin, which includes the Carrabassett River. Gilman Pond and its tributaries support significant natural populations of brown and brook trout. Gilman Dam presently is a boundary for small mouth bass, impoundment would provide smallmouth bass with an avenue to invade Sandy Stream and could compete with trout. Maine Division of Inland Fish and Wildlife is concerned that the introduction of smallmouth bass to Sandy Stream and other tributaries could negatively impact trout populations.

B.3.b. Sandy River. The Sandy River subbasin has a drainage area of approximately 593 square miles. The Maine Rivers Study designates all 69 miles of the Sandy River as a Class "B" river.

Water quality classifications for the Sandy River are Class A for the section above Phillips; Class B from Phillips to Farmington; and Class C from Farmington down to the Kennebec River.

The dam would be located in the area previously proposed for the Greenleaf Dam project (NYNIAC, 1955) The face of the dam would be located about a mile southwest of the stream gage station in Witham Corner between the towns of Starks and Mercer. A dike would be constructed just west of Bog Stream near Mercer, and a spillway would be designed near Lemon Creek.

The dimensions of the dam would be 3,000 feet long, 800 feet wide and 90 feet high. This would displace approximately 55.1 acres (2,400,000 square feet) of habitat. The dike near Bog Creek would displace approximately 4.6 acres (200,000 square feet) and the spillway at Lemon Creek another 1.4 acres (60,000 square feet) of habitat. Total area displaced by structures in the area would be approximately 61.1 acres (2,660,000 square feet). Approximately 217.7 acres would be selectively cleared of vegetation, reducing the wildlife value of the area.

The footprint of the impoundment at full capacity which corresponds to the 420 foot contour elevation would extend approximately 16 miles upstream, encompassing an area of approximately 7,189.7 acres (Fig B.3.b). The lower 3 miles of Josiah Brook and the lower 1 mile of Fillibrown Brook would be inundated at full impoundment.

The Sandy River valley affected by the flood control reservoir is covered with a mosaic of deciduous and mixed forest. Forest tree species include red oak, red, silver and sugar maple, ash, box elder, white, yellow and gray birch, black cherry, white pine. eastern hemlock, quaking aspen, balsam poplar, and American beech. Comparison with soil surveys (SCS, 1988) indicate that prime agricultural land within the basin would not be impacted by impoundment.

Riverine and palustrine wetlands are present along the river channel. Riparian and wetland plants include speckled alder, spirea, red-osier dogwood, willow, honeysuckle, Joe-Pye-weed, arrowwood, and wild raisin.

Wildlife habitat in the Sandy River valley is of very high quality due to the interspersion of cover types and the presence of highly productive bottomland hardwood forests. Summer range for big game is excellent. The basin provides breeding, resting and feeding habitat for a variety of waterfowl. Black duck and Canada geese use agricultural fields in the area as a stopover during the fall migration. Mallards, black duck and mergansers are among the breeding waterfowl. Woodcock are important game birds. A number of raptors occur within the basin, including red-tailed hawk, broad-winged hawk, red-shouldered hawk and the kestrel. Bald eagles may be a year-round residents. Peregrine falcons have been observed passing through the basin.

The Sandy River offers a wide range of aquatic habitat conditions throughout the affected reach. The river bottom is quite productive and provides a substantial food base for fish resources. The most abundant game fish species in the lower reaches of the Sandy River is the smallmouth bass. Brown and brook trout are more common in the upper reaches. These are natural production fisheries, stocking has been discontinued. Catadromous American eels are able to pass downstream dams on the Kennebec River and are common in the Sandy River. Anadromous fish restoration plans are dependent on substantial habitat contributions by the Sandy River. The Sandy has the highest potential for Atlantic salmon of any of the mainstem or tributary areas of the Kennebec. The shad restoration plan assumes there will be shad production in the Sandy River from the mouth to Farmington. Lemon Stream supports a seasonal cold-water fishery.

C. Coordination with Federal and State Agencies

1. U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS), Ecological Services, Concord Field Office, participated in field visits with Corps staff to the study area July and August, 1988. A planning aid letter providing environmental input and raising FWS concerns was received from FWS September 19, 1988.

2. National Marine Fisheries Service

Informal coordination with NMFS revealed that an endangered species consultation would likely be required to address impacts to the shortnosed sturgeon for projects south of Augusta.

3. U.S. Environmental Protection Agency

EPA has been informed of the project. They were unable to participate in the field visit.

4. State of Maine

Coordination with the state of Maine was initiated July 27, 1988. Meetings were held with Region B and Region D resource biologists August 23 and 24, 1988. Input from these meetings were incorporated into the reconnaissance report.

<u>Department of Economic and Community Development</u>
Tom Marcotte, Community Development Planner

<u>Department of Environmental Protection</u>
Shoreland Zoning
Dan Pritchard

<u>Department of Marine Resources</u>
Division of Marine Fisheries
Thomas Squeire

<u>Department of Inland Fisheries and Wildlife</u>
Steve Timpano, Environmental Coordinator
Dennis McNeish, Fishery Biologist, Region B
Eugene Dumant, Wildlife Biologist, Region B
Peter Cross, Wildlife Biologist, Region D
Ray DeSandre, Fishery Biologist, Region D

D. Feasibility Study Estimates

Environmental studies include preparation of an Environmental Assessment as well as coordination with Federal, State and local resource agencies. Money would need to be allocated to U.S Fish and Wildlife services for the preparation of the Fish and Wildlife Coordination Act Report and Endangered Species Consultation. The EA would be used to determine the need for and Environmental Impact Statement. Inclusion of Dams in the plan would almost certainly require the preparation of an EIS.

- Environmental Assessment
  - Preparation of Report (IAB)
  - Fish and Wildlife Coordination Act Report (FWS)
  - Endangered Species Consultation (FWS and NMFS)
- Environmental Impact Statement
  - Preparation of Report (IAB)
    - Habitat Evaluation Study for Reservoir Basins.
    - Instream Flow Incremental Impact Assessment
    - Fishway Design Study
  - Fish and Wildlife Coordination Act Report (FWS)
  - Endangered Species Consultation (FWS and NMFS)

E. REFERENCES.

Canter, L. 1985. Environmental Impact of Water Resources Projects. Lewis Publishers Inc, Chelsea MI.

CMP. 1986. Amended application for new license for the Williams Project on the Kennebec River in Bingham, Concord, Embden and Solon Maine by Central Maine Power Company, Augusta Maine. Volume II. Exhibit E.

EPA. 1975. Guidelines for EPA Review of Environmental Impact Statements on Projects Involving Impoundments. Final Report.

Hynson, J.R., P.R. Adamus, J.O. Elmer, T. DeWan and F.D. Shields, Jr. 1985. Environmental Features for Stream-side Levee Projects. Technical Report E-85-7, prepared by the Center for Natural Areas, South Gardiner, Maine, and the Environmental Laboratory, Waterways Experiment Station, for the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Maine, DEC. 1982. Maine Rivers Study, Final Report. Prepared by State of Maine, Department of Conservation and U.S. Department of the Interior, National Park Service, Mid-Atlantic Regional Office.

Maine, DEP. 1988. State of Maine 1988 Water Quality Assessment. Maine Department of Environmental Protection, Bureau of Water Quality Control. Augusta, ME.

Maine, DEP. 1987. Maine Water Classification Program. Maine Department of Environmental Protection, Bureau of Water Quality Control. Augusta ME.

NERBC, 1989. Kennebec River Basin Overview. New England Rivers and Basin Commission.

Nunnally, N.R and F.D. Shields. 1985. Incorporation of environmental features in flood control channel projects. Technical Report E-85-3. U.S. Army Engineer Waterways Experiment Station. Vicksburg, Miss.

NYNIAC, 1955. The resources of the New York Region, Part Two, Chapter VI. Kennebec River Basin, Maine. New England - New York Interagency Committee.

Petts, G.E. 1980. Long-term consequences of upstream impoundment. Environmental Conservation 7 (4): 325-332.

Petts, G.E. 1980. Morphological changes of river channels consequent upon headwater impoundment. Journal of the Institution of Water Engineers and Scientists 34 (4): 374-382.

SCS. 1988. Soil Conservation Survey, Somerset County.

SCS. 1988. Soil Conservation Survey, Franklin County.

Trotsky, H.M. and R.W. Gregory. 1974. The effects of water flow manipulation below a hydrographic power dam on the bottom fauna of the Upper Kennebec River, Maine. Transactions of the American Fisheries Society 103: 318-324.

SECTION III

ECONOMIC ANALYSIS

Kennebec River Basin
Reconnaissance Study

Economic Analysis

January 1989

KENNEBEC RIVER BASIN

RECONNAISSANCE STUDY

ECONOMIC ANALYSIS

Table of Contents

Introduction

The purpose of the economics section is threefold. The first is the specification of the flood loss potential as relates to the existing without project condition in the Kennebec River Basin. This will be accomplished by delineating significant flood damage centers, identifying floodplain activities and estimating recurring losses and expected annual losses. Secondly, inundation reduction benefits will be estimated for structural and nonstructural improvement plans. Thirdly, each plan's measure of economic justification will be determined through calculation of a benefit/cost ratio. Net benefits for each plan will also be presented. The economic analysis is performed at the reconnaissance level of detail. Annual losses and benefits reflect the October 1988 level of prices.

Overall Study Area

Based on problem identification efforts of the project manager and project team and close coordination with State of Maine officials, the following 12 areas were identified as having the most significant existing flood loss potential and required focused study: Anson, Augusta, Fairfield, Farmington, Gardiner, Hallowell, Madison, Pittsfield, Randolph, Skowhegan, Waterville, Winslow.

Flood Damage Survey

A flood damage survey was performed in the 12 areas by an NED flood damage evaluator during July to September 1988. Flood related losses were estimated for each floodprone structure and site beginning at the elevation at which discernable losses and damages are first incurred up to the flood elevation of a rare and infrequent (500 year) event. The reference point at each structure was the first floor elevation. In addition to the NED flood damage survey effort, a local architect-engineer firm was contracted with to perform a nonstructural investigation for the 12 areas. As part of this contract, ground and first floor elevations were obtained for all structures in the 100-year floodplain. These elevations provided an additional level of confidence in the estimates of annual losses and benefits. The NED damage evaluator conducted interviews with knowledgeable local people concerning flood losses to commercial, industrial and public activities. For residential properties, use of sampling, typical loss profiles by type of house and minimal interviewing were employed. Both physical and non-physical losses were estimated. The cost of emergency services where obtained were possible. Damages to transportation, communication and utility systems were also obtained from the towns, the State of Maine Dept. of Transportation and the Central Maine Power Co.

Recurring Losses

Recurring losses are those potential flood related losses which are expected to occur at various stages of flooding under present day development conditions. As the final output of the flood damage survey process, recurring losses are expressed as an array of dollar losses, in one foot increments, from the start of damage to the elevation of a rare and infrequent (500 year) event. Total recurring losses for selected events in the damage centers of the cities and towns under investigation are displayed in Table 1.

Table 1
Recurring Losses

Location	Recurring Losses-By Event			
	10 Year	50 Year	100 Year	500 Year
Anson	$ 0	$ 30,500	$ 122,300	$ 574,500
Augusta	93,000	1,828,100	3,381,900	5,710,900
Fairfield	1,400	445,800	1,543,500	4,303,000
Farmington	281,300	1,373,300	1,833,700	1,975,000
Gardiner	1,237,000	5,191,800	5,579,500	5,851,000
Hallowell	126,000	1,973,000	2,284,500	2,432,000
Madison	0	0	3,026,000	3,035,000
Pittsfield	155,800	272,200	317,100	347,700
Randolph	277,600	918,900	1,074,000	1,222,100
Skowhegan	0	417,000	3,212,000	5,557,800
Waterville	0	1,032,000	2,235,000	4,547,500
Winslow	91,500	1,935,700	2,840,400	2,845,400
TOTAL	$2,263,600	$15,418,300	$27,449,900	$38,401,900

Annual Losses

The purpose of estimating annual losses is to measure the severity of potential flooding on an "expected annual" basis in each damage center. Annual losses are the integration and summation of two sets of data at each damage location. Recurring losses for each flood elevation (event) are multiplied by the annual percent chance of occurrence that each specific flood elevation (event) will be reached. The effectiveness of each alternative flood reduction plan is measured by the extent to which it reduces annual losses. Annual losses in the damage centers of the 12 cities and towns are displayed in Table 2.

Table 2
Annual Losses

Location	Annual Losses
Anson	$ 5,000
Augusta	209,400
Fairfield	55,000
Farmington	125,400
Gardiner	425,000
Hallowell	117,100
Madison	93,400
Pittsfield	95,900
Randolph	110,800
Skowhegan	69,400
Waterville	80,100
Winslow	118,300
TOTAL	$1,504,800

Improvement Plans

Both structural and nonstructural plans were formulated to reduce flood related losses in the basin. The structural plans involve: (i) reservoir sites on the Sandy and Carrabasset Rivers and (ii) local protection projects consisting of walls and dikes in each of the cities and towns. The nonstructural plans address: (i) raising first floors of structures and (ii) installation of closures.

Benefit Estimation Methodology

Benefits were estimated for the different types of improvement plans by use of the following methods. Structural plans: Reservoirs - Annual losses were compared under the with and without project conditions for the 8 basin towns affected. Natural and modified stage-frequency curves were employed. Benefits to the reservoir are the difference in annual losses under the two conditions. Dikes and Walls - Annual losses prevented under existing conditions were calculated up to the specific level of protection (elevation) plus 50 percent of the freeboard range. Nonstructural plans: Raising of First Floors - Annual losses to each structure were compared without the plan (first floor at existing elevation) and with the plan (first floor raised to one foot above the 100 year flood level). Benefits are the difference in total annual losses. Closures - Annual losses were estimated for each building only for those damage categories that closures would prevent. For example, contents and structures were included, but non-physical losses and grounds were not. Benefits were calculated as reduced annual losses up to the level of protection. All closure plans were evaluated at the 100 year level of protection.

Reservoir Plan

Flood control reservoirs on the Sandy and Carrabasset Rivers would act in tandem and result in the reduction of flood stages in 8 of the 12 cities and towns under investigation. Table 3 below shows the benefits that would accrue to each town and also the percent reduction in flood losses caused by the reservoirs.

Table 3

Reservoir Plan

Location	Annual Losses w/o Reservoirs	Annual Losses W/Reservoirs	Annual Benefits	% Reduction in Losses
Skowhegan	$ 69,400	$ 100	$ 69,300	99%
Waterville	80,100	4,400	75,700	95%
Winslow	118,300	10,900	107,400	91%
Fairfield	55,000	3,500	51,500	94%
Augusta	209,400	15,800	193,600	92%
Hallowell	117,100	13,900	103,200	88%
Randolph	110,800	41,100	69,700	63%
Gardiner	425,000	178,100	246,900	58%
TOTAL	$1,185,100	$267,800	$917,300	77%

Specific Study Areas and Improvement Plans

In the following analysis of the 12 specific study areas, individual damage centers in each town will be examined in terms of floodplain activities, floodplain characteristics, recurring losses and annual losses. Benefits will be estimated for each local plan of improvement, both structural and nonstructural, and a benefit/cost ratio and net benefits will be calculated for each.

(1) ANSON, ME

In Anson, a total of 12 buildings, 6 commercial land 6 residential, along Main St. were identified as floodprone. However, they will not experience significant damages until the occurrence of events approaching the 100 year storm.

Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Anson	0	$30,500	$122,300	$574,300	$5,000

Annual losses of $5,000 precluded the formulation of structural alternatives due to the slight chance of economic justification. Benefits were estimated for one nonstructural plan which attempts the dry floodproofing 9 buildings through the installation of closures over openings in the structure. This plan is not economically justified.

Nonstructural Plan
Closures

Annual Benefits	$ 1,000
Annual Cost	28,000
Benefit/Cost Ratio	.04 to 1
Net Benefits	-

(2) AUGUSTA, ME.

The main damage center in Augusta is the downtown commercial area along Water St. From the recurring loss table it can be seen that significant flood losses to this mixed area of commercial and residential activities begin at the 50 year flood event. In total, 40 structures are affected.

Recurring Losses-By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Augusta	$93,000	$1,828,100	$3,381,900	$5,710,900	$209,400

Structural alternatives formulated to reduce the flood loss potential in this area are: (i) earthen dikes and (ii) concrete T-walls. Both 50 year and 100 year protection plans were evaluated. A nonstructural plan was formulated which involved the installation of closures to seal the openings in 24 structures up to the 100 year flood elevation.

Improvement Plans - Augusta

	Dikes		Walls		Nonstructural
	50 yr	100 yr	50 yr	100 yr	Closures
Annual Benefits	$152,000	$173,300	$152,000	$ 173,300	$155,000
Annual Costs	357,000	426,000	822,000	1,074,000	83,000
Benefit/Cost Ratio	.43 to 1	.41 to 1	.18 to 1	.16 to 1	1.87 to 1
Net Benefits	-	-	-	-	$ 72,000

(3) FAIRFIELD, ME.

There are two separate damage centers in Fairfield. Located in the Water St. area is a sewage treatment plant, a church and 25 houses. In the Upper Main St. area are 17 residential structures, 4 commercial and a trailer park containing 47 mobile homes. Recurring losses are nearly equal for the two separate areas and become significant at events approaching the 100 year event.

Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Water St.	0	$252,000	$ 827,500	$1,468,900	$22,100
Upper Main St.	$1,400	193,800	716,000	2,834,100	32,900
Total Fairfield	1,400	445,800	1,543,500	4,303,000	55,000

Structural plans of improvement for Fairfield involve the evaluation of (i) earthen dikes and (ii) T-walls at the 50 and 100 year levels of protection. Two nonstructural measures were formulated. The first involves the raising of the first floor a 37 residential structures to one foot above the 100 year flood level. The second is the installation of closures to seal openings in 56 residential structures, 4 commercial and 5 public buildings to protect against the 100 year flood.

Structural Improvement Plans - Fairfield

	Dikes		Walls	
	50 yr.	100 yr.	50 yr.	100 yr.
Annual Benefits	$ 12,100	$ 23,400	$ 12,100	$ 23,400
Annual Costs	354,000	491,000	558,000	842,000
Benefit/Cost Ratio	.03 to 1	.05 to 1	.02 to 1	.03 to 1
Net Benefits	-	-	-	-

Nonstructural Improvement Plans - Fairfield

	Raising (37 bldgs)	Closures (65 bldgs)
Annual Benefits	$ 9,800	$ 17,800
Annual Costs	151,900	70,000
Benefit/Cost Ratio	.06 to 1	.26 to 1
Net Benefits	-	-

(4) FARMINGTON, ME.

A total of 32 structures were identified as having flood loss potential in Farmington. Located along Water St. and Lower Main St., the structures are nearly evenly divided among residential (15) and commercial (16) with one public building. Twenty-eight of the 32 structures have first floor elevations below the 100 year flood elevation which results in considerable recurring losses at the more frequent flooding events.

	Recurring Losses - By Event				
	10 Year	50 Year	100 Year	500 Year	Annual Losses
Farmington	$ 281,300	$1,373,300	$1,833,700	$1,975,000	$125,400

The structural plan of improvement was an earthen dike along Water Street that would protect 15 commercial properties. Nonstructural plans consisted of (i) raising the first floor of 5 residences and (ii) providing closures for all 32 structures.

Structural Improvement Plans - Farmington	Dikes		Walls	
	50 Year	100 Year	50 Year	100 Year
Annual Benefits	$43,000	$49,300	$43,000	$49,300
Annual Costs	62,000	86,000	100,000	142,000
Benefit/Cost Ratio	.69 to 1	.57 to 1	.43 to 1	.34 to 1
Net Benefits				

Nonstructural Improvement Plans - Farmington

	Raising (5 bldgs)	Closures (32 bldgs)
Annual Benefits	7,700	74,600
Annual Costs	20,500	68,000
Benefit/Cost Ratio	.38 to 1	1.1 to 1
Net Benefits	-	6,600

(5) GARDINER, ME.

There are 56 commercial structures in Gardiner that have a strong potential to experience flood losses. This is because the majority of the buildings have first floors at an elevation 5 to 8 feet below the 100 year flood elevation. Cobbosseecontee Stream flows through this area before joining the Kennebec and contributes to flood damage by backing up and rising when the Kennebec is at high stages. This stream also divides the 56 building damage center into 2 distinct parts. One part, the Main St. area, contains 47 structures while the other, the Shop 'N Save mall area contains 9. As expected, recurring losses are high for Gardiner.

Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Gardiner	$1,237,000	$5,191,800	$5,579,500	$5,851,000	$425,000

The structural plan that was formulated for the commercial buildings is an earthern dike evaluated at 50 and 100 year levels of protection. The nonstructural plan provides closures for all of the structures.

Structural Improvement Plan - Gardiner

	Dike	
	50 Year	100 Year
Annual Benefits	$356,000	$395,000
(Main St. Area)	(166,000)	(194,000)
(SNS Mall Area)	(190,000)	(201,000)
Annual Cost	399,000	444,000
Benefit/Cost Ratio	.89 to 1	.89 to 1
Net Benefits	-	-

Nonstructural Improvement Plan - Gardiner

Closures - 56 Buildings

Annual Benefits	197,600
Annual Cost	215,000
Benefit/Cost Ration	.92 to 1
Net Benefits	-

(6) HALLOWELL, ME.

Flood losses in Hallowell are concentrated in 30 commercial (retail) structures along both sides of Water St. The majority of these establishments are antique shops, book stores or restaurants. Most of the buildings have first floors at elevations 4 to 8 feet below the 100 year flood elevations. Recurring losses therefore become substantial at events approaching the 50 year flood.

Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Hallowell	$126,000	$1,973,000	$2,284,500	$2,432,000	$117,100

Structural improvements formulated to protect this area of Water St. were (i) dikes and (ii) walls that were evaluated for 50 and 100 year levels of protection. Nonstructural plans are (i) raising the first floors of 9 buildings and (ii) installing closures in 20 residential structures, 47 commercial structures and 2 public buildings. Many of these buildings are outside of the concentrated retail area or Water St. and can not be protected by structural means.

Structural Improvements Plans - Hallowell

	Dikes		Walls	
	50 Year	100 Year	50 year	100 Year
Annual Benefits	$ 87,600	$102,000	$ 87,600	$102,000
Annual Costs	255,000	319,000	536,000	746,000
Benefit/Cost Ratio	.34 to 1	.32 to 1	.16 to 1	.14 to 1
Net Benefits	-	-	-	-

Nonstructural Improvement Plans - Hallowell

	Raising (9 bldgs)	Closures (69 bldgs)
Annual Benefits	$ 9,300	$256,000
Annual Costs	36,900	254,000
Benefit/Cost Ratio	.25 to 1	1.01 to 1
Net Benefits	-	-

(7) MADISON, ME.

Located directly across the Kennevec from Anson, the town of Madison has one floodprone area. Of the 5 buildings in this area, only one, a restaurant is not a large factory type of building. All of the buildings have first floors below the 100 year event, however the area currently has a private system of dikes and walls which provides 50 year protection with no freeboard allowance. Flood losses are concentrated in the Madison Paper Industries buildings.

Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Madison	0	0	$3,026,000	$3,035,000	$93,400

The structural improvement plan for Madison would increase the level of protection of the existing dike and wall to the 100 level with freeboard. The nonstructural plan would provide closures.

Improvement Plans - Madison

	Structural (Dike and Wall)	Nonstructural (Closures)
Annual Benefits	$42,000	$43,000
Annual Costs	67,000	17,000
Benefit/Cost Ratio	.63 to 1	2.5 to 1
Net Benefits	-	$26,000

(8) PITTSFIELD, ME.

The town of Pittsfield is located on the Sebasticook River and has a damage center which consists of 31 residential structures, 2 mobile homes, 1 commercial building and 1 public building. The majority of the houses have first floor elevations at or up to 2 feet below the 100 year flood event. Openings below the first floor range from 3 to 5 feet below the 100 year flood elevation. Significant flooding occurs at the more frequent flood events as there is only a 2 foot difference between the 10 year and 100 year flood level in the Pittsfield floodplain.

Recurring Losses - By Event

	10 Year	50 Year	100 year	500 Year	Annual Losses
Pittsfield	$155,800	$272,200	$317,700	$347,700	$95,900

Structural improvement plans for this area are (i) dikes and (ii) walls evaluated at the 50 and 100 levels of protection. Nonstructural improvement plans include (i) raising the first floors of 12 residences and (ii) installing closures in all of the structures in the floodplain.

Structural Improvement Plans - Pittsfield

	Dikes		Walls	
	50 Year	100 Year	50 Year	100 Year
Annual Benefit	$91,000	$94,100	$91,000	$94,100
Annual Costs				
Benefit/Cost Ratio				
Net Benefits				

Nonstructural Improvement Plans - Pittsfield

	Raising (12 bldgs)	Closures (37 bldgs)
Annual Benefits	$16,500	$69,300
Annual Costs	49,300	47,000
Benefit/Cost Ratio	.33 to 1	1.47 to 1
Net Benefits	-	22,300

(9) RANDOLPH, ME.

Randolph, located directly across the Kennebec River from Gardiner, Me., has a damage center comprised of 24 structures, the majority of which are residential. Only 3 buildings have first floor elevations at the 100 year flood level. The remainder vary from 3 to 10 feet below. Recurring losses therefore become significant at the more frequent flooding events.

Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Randolph	$277,600	$918,900	$1,074,000	$1,222,100	$110,800

Structural alternatives were not formulated for this site. Nonstructural plans include (i) raising the first floors of 4 houses and (ii) providing closures for all of the structures in the floodplain.

Nonstructural Improvement Plans - Randolph

	Raising (4 bldgs)	Closures (24 bldgs)
Annual Benefits	$20,300	$71,000
Annual Costs	16,400	56,000
Benefit/Cost Ratio	1.2 to 1	1.27 to 1
Net Benefits	$ 3,900	$15,000

(10) SKOWHEGAN, ME.

The damage center in Skowhegan consists of 18 residential structures, 4 commercial, 4 industrial and 2 public buildings. Roughly one-half of the structures have first floor elevations above the 100 year flood level, while the remainder average 1 to 3 feet below. Damages are not significant at the more frequent events. Even at the 50 and 100 year events, two-thirds of the losses are concentrated in two industrial concerns and a hydroelectric plan.

Recurring Losses - By Event

	10 Year	50 year	100 Year	500 Year	Annual Losses
Skowhegan	0	$417,000	$3,212,000	$5,557,800	$69,400

Structural plans for Skowhegan involved (i) dikes and (ii) walls, both 1,500 feet in length, to protect residential structures along Elm and Pleasant Streets. Due to the first floor elevations being above the level of frequent flooding, benefits were minimal and neither the 50 nor the 100 year plans were justified. Both had length/cost ratios less than 0.1 to 1. Nonstructural plans investigated (i) raising the first floors of 9 residences and (ii) providing closures for all floodprone structures.

Nostructural Improvement Plans - Skowhegan

	Raising (9 bldgs)	Closures (21 bldgs)
Annual Benefits	$ 2,600	$ 17,200
Annual Costs	36,900	113,000
Benefit/Cost Ratio	.07 to 1	.15 to 1
Net Benefits	-	-

(11) WATERVILLE, ME.

The damage center in Waterville consists of 23 structures. Three properties account for the majority of the flood losses. These are the Hathaway Factory, the Central Maine Power Facility and the Sewage Treatment Plant. At the 50, 100 and 500 year event 3 activities account for 90, 90 and 85 percent respectively of recurring losses. The remaining number of properties is evenly divided between residences and commercial (retail) structures. One-half of the first floors of these buildings are at the 100 year flood level and the remainder range from 1 to 4 feet below.

Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Waterville	0	$1,032,000	$2,235,000	$4,547,500	$80,100

The structural plan of improvement for Waterville is a 1,500 foot earthern dike. The nonstructural plan will provide closures for all floodplain structures.

Improvement Plans - Waterville

	Structural (Dike)		Nonstructural (Closures)
	50 Year	100 Year	
Annual Benefits	$ 31,400	$ 54,300	$12,000
Annual Costs	109,000	142,000	80,000
Benefit/Cost Ratio	.28 to 1	.38 to 1	.15 to 1
Net Benefits	-	-	-

(12) WINSLOW, ME.

Of the 21 structures in the Winslow damage center, 4 are houses, 2 are public buildings and the remainder are commercial. All of the buildings have first floor elevations below the 100 year flood level, with many from 5 to 10 feet below. Losses become significant at the more frequent flooding events.

Recurring Losses - By Event

	10 Year	50 Year	100 Year	500 Year	Annual Losses
Winslow	$91,500	$1,935,700	$2,840,700	$2,845,400	$118,300

Structural improvement plans for Winslow include (i) dike and (ii) walls evaluated at 50 and 100 year levels of protection. The nonstructural plan provides closure for all floodprone structures.

Structural Improvement Plans - Winslow

	Dikes		Walls	
	50 Year	100 Year	50 Year	100 Year
Annual Benefits	$ 73,300	$104,000	$ 73,300	$104,000
Annual Costs	299,000	399,000	678,000	1,012,000
Benefit/Cost Ratio	.24 to 1	.26 to 1	.11 to 1	.10 to 1

Nonstructural Improvement Plan - Winslow

	Closures
Annual Benefits	$53,400
Annual Costs	74,000
Benefit/Cost Ratio	.72 to 1
Net Benefits	-

SECTION IV

SECTION 22 STUDY
HYDROLOGY OF FLOODS
KENNEBEC RIVER BASIN
PART II

EXECUTIVE SUMMARY

This report presents Part II of a hydrologic analysis of flooding in the Kennebec River basin. The study was conducted by the Corps of Engineers under the authority contained in Section 22 of the Water Resource Act of 1972. This study was undertaken at the request of the State of Maine.

In September 1985, the Corps of Engineers completed Part I of the investigation entitled "Hydrology of Floods, Kennebec River, Maine." The study reviewed available hydrologic data on floods and analyzed the development and component contributions of recent floods on the river, most notably; December 1973, April 1979, Spring 1983 and June 1984. The document presented here entitled: "Hydrology of Floods, Part II" addressed the effects of storage reservoirs in the basin on Kennebec River flood development.

The Part II study explored the development of reservoir regulation guidance which might further maximize the incidental flood reduction potential of the upper basin storage facilities, without impacting their hydropower function. All season reservoir regulation guide curves were developed by trial through multiyear sequential hydrologic system simulation. Simulations, using the developed guide curves, indicated that greater reservoir storage could be realized with little impact to the downstream flow regime. Storage capacity equivalent to 6 inches of runoff would be available about 65 percent of the time as compared to 40 percent under actual operations. Guide curve operation would likely minimize the spillage during nonspring refill floods, but would not completely prevent spillage during critical spring refill season floods such as the April 1983 and June 1984 floods. When abnormal spring runoff occurs spillage is inevitable. Therefore, secondary guidance was explored in an effort to modify peak discharge rates of spillage when spillage is eminent. Applying the guidance to the experienced April 1979, April 1983 and June 1984 flood events indicated potential reductions of about 30 percent in peak rates of spillage.

A review of surcharge storage characteristics at the three major storage reservoirs revealed no opportunities for any significant added use of surcharge storage for flood control purposes.

A cursory analysis was made of the relative effectiveness of any new flood control storage in various presently uncontrolled subwatersheds upstream of Waterville, Maine. Resulting average main stem flood stage reduction per 100,000 acre-feet of storage varied from about 1.0 to 2.5 feet for different subwatersheds with the maximum effectiveness indicated for the Carrabassett tributary. A component contribution analysis of the recent major Kennebec River flood of March/April 1987 demonstrated the

flood producing potential of runoff from the uncontrolled downstream watersheds. This spring flood was the flood of record generally throughout the mid to lower Kennebec basin and occurring with upper basin reservoirs controlling the runoff from their contributing watersheds. Had it not been for the availability of upper basin reservoir storage, the devastating flood of 1987 would have been considerably worse.

In summary, the Part I and II reports provide hydrologic information, analysis, and guidance in the interest of facilitating a common understanding for planning and designing flood damage reduction projects and programs. The study reveled two flood reduction opportunities on the main stem of the Kennebec River. The adoption of monthly guide curves for the major storage reservoirs in the upper basin could reduce the effective runoff contribution from these watersheds. In the uncontrolled watersheds above Waterville, Maine, potential flood stage reduction could be achieved through the development of additional flood control storage. The amount of flood stage reduction is dependent upon the location of the storage facility.

This study was performed under the Corps of Engineers' Section 22 Program administered by Messrs. John R. Kennelly and John E. Kennedy of the Corps of Engineers, Planning Division, under the direction of Mr. Joseph L. Ignazio. The hydrologic investigation was completed by Messrs. Philip Manley and Mark Gieb of the Hydrologic Engineering Section under the direction of Mr. Richard D. Reardon.

HYDROLOGIC ANALYSIS OF FLOODS
KENNEBEC RIVER
MAINE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

HYDROLOGIC ANALYSIS OF FLOODS
KENNEBEC RIVER, MAINE
PART II

1. PURPOSE

This Part II report, on the "Hydrologic Analysis of Floods" in the Kennebec River, presents:

a. The results of exploratory system simulation studies in search of reservoir regulation guidance that might maximize the incidental flood control effectiveness of upper basin reservoirs while not impacting their design purpose, i.e., hydropower storage.

b. Information on the relative flood control effectiveness if new reservoir storage were provided in various uncontrolled tributary watersheds.

c. An assessment of the potential for added flood control surcharge storage at the existing upper basin reservoirs.

These issues were studied, at the request of the Maine State Planning Office, as a continuation of the original (Part I) 1985 study report. Also included in this report is a summary hydrologic analysis of the recent major March/April Kennebec River flood.

2. BACKGROUND

In September 1985, the Corps of Engineers completed a study report entitled: "Hydrology of Floods, Kennebec River, Maine." The study was performed for the Maine State Planning Office under authority contained in Section 22 of the Water Resources Development Act (PL 93-251) of 1974. Included in the earlier report were sections on basin description, climatology, streamflow and flood history. Its purpose was to review available hydrologic data on floods and analyze the development, and component contributions, of recent floods on the river, most notably: December 1973, April 1979, April 1983 and June 1984.

As a followup to this earlier report, the State requested Part II studies exploring (a) seasonal "guide curves" for regulating the large headwater storage reservoirs (Brassua, Moosehead and Flagstaff), in the interest of possibly enhancing incidental flood control and, (b) the relative effectiveness if new flood control storage were built on selected uncontrolled tributaries, as well as the potential of surcharge storage use at existing reservoirs.

A map of the Kennebec River basin is shown on plate 1. Principal tributaries and existing reservoir storages are listed in tables I and II.

TABLE I

KENNEBEC RIVER
PRINCIPAL TRIBUTARIES

Tributary	Drainage Area (sq.mi.)*	Length (miles)	Fall (feet)
Moose River	722	76	750
Dead River	874	23	570
Carrabassett River	401	35	636
Sandy River	596	69	1544
Sebasticook River	946	48	270

* U.S. Geological Survey, Open File Report, "Drainage Areas of Rivers and Streams in the Kennebec River Basin," September 1980.

3. RESERVOIR GUIDE CURVES

a. General. Ten hydroelectric dams on the main stem of the Kennebec River make up 95 percent of the total hydropower generating capacity in the Kennebec basin. All the main stem dams are "run-of-river" except Harris (Indian Pond) and Wyman which have storage capacity only for daily or weekly load fitting operations. Principal storage reservoirs in the basin are in the headwaters above Bingham and are used for hydropower regulation. There are 1,132,000 acre-feet of storage in the basin and 1,016,500 acre-feet, or 90 percent, are at the three lakes: Brassua, Moosehead and Flagstaff.

Storage reservoirs are used in hydropower operations to store excess waters during high flow periods for later release and use during low flow periods, thereby, ensuring a

TABLE II

AVAILABLE RESERVOIR STORAGE*
KENNEBEC RIVER BASIN ABOVE BINGHAM, MAINE

Project	Drainage Area (sq.mi.)**	Surface Area (acres)	Drawdown (feet)	Storage (ac-ft)	Percent
Brassua Lake	716	8,979	30	196,500	17
First Roach Pond	70	3,270	7	21,500	2
Moosehead Lake	1,268	74,000	7.5	544,000	48
Indian Pond (Harris)	1,384	3,747	5	19,000	2
Moxie Pond	80	1,747	8	14,700	2
Flagstaff Lake	516	17,950	35	276,000	24
Wyman Lake	2,619	3,145	20	60,300	5
				1,132,000	100

* Storage Data from U.S. Geological Survey Water Data Report ME-83-1

** From U.S. Geological Survey, Open File Report, "Drainage Areas of Rivers and Streams in the Kennebec River Basin," September 1980 minimum dependable hydropower generation. From a hydropower perspective, water in storage is "money in the bank" and releases in excess of hydropower capacity, are "spillage" or "wastage" and represent revenue lost.

Therefore, reservoir regulation for hydropower generally involves trying to maintain sufficient water in storage to provide hydropower dependability while at the same time maintaining storage space in anticipation of excess runoff. Because of limited storage capacity the majority of hydropower reservoirs are used as "pondage" primarily for daily or weekly "load fitting" operations. It is only the real large storages such as Brassua, Moosehead, and Flagstaff that are of such size as to permit seasonal storage regulation. These storages are generally filled each spring during the snowmelt high flow season and then drawn down during the following summer, fall and winter seasons. The three Kennebec headwater storages are operated as a system to provide a lower main stem flow for hydropower.

Hydropower storage reservoirs, with no design storage for flood control, cannot ensure floodflow reductions during all floods; however, during periods when storage is drawn down for hydropower, their ability to store storm runoff does provide a degree of incidental flood control. The degree of such incidental flood control benefit is a function of the percent of time, and amount, the reservoir is drawn down in its hydropower operation. Such incidental flood control benefits are real if the reduced frequency of flooding does not create public complacency on the part of downstream flood plain occupants, resulting in more flood plain development and thus increased flood damages when the less frequent but unmodified floods do occur. Therefore, appropriate flood plain zoning is a vital feature of any water resource management plan involving incidental flood control by nonflood control reservoirs.

The purpose of the study, reported herein, was to explore the development of reservoir regulation "guide curves" that might tend to maximize the incidental flood control provided by the three upper basin reservoirs, while at the same time not impact on their hydropower function. The exploration studies were facilitated by computer hydrologic system simulations.

b. Procedure. In summary, the study procedure was as follows: the three-reservoir system operation was first simulated for a historical hydrologic period of years to determine the minimum dependable yield of the system during critical drought periods. Secondly, having established the minimum dependable yield and knowing the average system yield, a series of trial simulations were made to establish monthly target release rates, as a function of amount of water in storage (guide curves), that would tend to: (1) maximize regulated flows during normal periods, (2) minimize spillage and wastage during wet periods, and (3) still maintain sufficient water in storage to meet minimum dependable yield during critical drought periods. Striving to meet the above goals would tend to maximize hydropower capability but also maximize incidental flood control storage availability. All system simulations were performed with the aid of the Corps of Engineers computer program HEC-5, "Simulation of Flood Control and Conservation Systems," using a monthly time increment. Streamflow data (system inflow) was determined using the published flow data for the Kennebec River at the Bingham, Maine U.S. Geological Survey gage and adjusting for monthly change in upstream reservoir contents. This computed monthly flow data was then prorated by respective drainage area size to determine monthly reservoir inflows and contributions from uncontrolled local areas. The system was first simulated for the period 1951 to 1984 (34 years) to establish minimum yield. The period 1955 to 1975 (21 years) was then selected as a representative hydrologic period and used as the test period for the numerous subsequent trial simulations.

Though the three reservoir system is operated for a series of main stem hydropower plants, for these simulations the reservoirs were operated for a single main stem index point, that being the Bingham USGS gage site located a short distance downstream of the second largest hydropower project on the Kennebec: Wyman Dam. All hydrologic simulation and guide curve development studies were intentionally made completely independent of any existing or historical operational trends or procedures, thereby, avoiding any prestudy bias or preconceived operational criteria.

Brassua and Moosehead Lakes are two reservoirs in tandem and they operate in parallel with Flagstaff Lake in providing flows to Wyman and other downstream hydropower plants. As previously stated, the three-reservoir system, plus the intervening uncontrolled local, was operated for the Bingham gage as the single downstream index control point. Operating criteria for individual reservoirs was selected to maintain the three storages generally in balance with respect to percentage of total usable storage capacity. The only exception was that when first initiating drafting from full reservoirs, drafting, from Moosehead would precede drawing from Brassua, thus minimizing the possibility of drafting at Brassua while spilling at Moosehead. Similarly, at the lower extreme of storage utilization, Brassua would be emptied before Moosehead to try and avoid Moosehead not being able to meet downstream control flow while there was still water in storage at Brassua.

Guide curves, both monthly and seasonally, were developed by trial simulations and by analysis of average and drought runoff periods. The monthly "guide curves" took the following form. Each month there was an established target flow at Bingham. If total system water in storage was within limits established for the specified month then the system was operated to meet the target flow. If for any month the total system storage fell below the established lower limit, the system would operate for a lower limit minimum flow at Bingham. Similarly, if system storage exceeded the upper limit, the system was operated for an upper limit flow at Bingham. Obviously, in the event inflows minus requested outflows exceeded available storage at any of the three reservoirs, then all excess inflows, above storage capacity, were released downstream.

It is noted that with the simulation used, there were three control flow conditions for each month, either desired flow, minimum flow, or maximum flow. It would be expected that, in an actual day-to-day operation, transitional rather than stepped guide curves would be used to relate control flow versus total system storage.

c. Results. The resulting monthly "guide curves" of Bingham target flow versus total system storage, developed by trial, are shown on plate 2. The simulation studies demonstrated, as is commonly known, that storage refill is generally during the spring runoff period (April to May). Drawdown can commence generally in July and continue throughout the year to the beginning of the subsequent spring refill period. The degree to which storage can be filled in the spring determines the project's ability to ensure a minimum dependable flow throughout the coming year. Progressing through the year, the length of time to the next refill becomes less; therefore, the amount of reserve storage required becomes progressively less. By simulation of several years, sequentially, the monthly minimum storage levels are established which would necessitate going to minimum flow, but, equally important, upper limits are established indicating likely excess of storage to meet normal flow. Excess storage can be released for downstream use, which may reduce later spillage (wastage) during high flow. It is the use and orderly release of excess seasonal storage that would tend to maximize incidental flood control.

As the guide curves indicate, the minimum dependable yield of the system at the index point, Bingham, was found to be about 2,000 cfs, with a normal capability of about 4,000 cfs. The guide curves were developed with an all season minimum required target flow of 2,000 cfs, and all season desired target flow of 4,000 cfs except April. Following a series of simulations, the desired target flow for April was increased to 8,000 cfs in trying to reduce the frequency and magnitude of spillage from filled storages during spring run-off. Maximum target flow was set at 6,000 cfs from June through February with 8,000 for March, 10,000 for April and 8,000 for May.

It is noted that these upper limit release rates are in excess of the hydropower capacity of many of the main stem projects. Maximum capacity in the system is at Wyman, at about 9,000 cfs. The guide curves simply indicate that, at times, the system can provide these higher flows without impacting on later required flow capability and possibly reducing later spillage rates from the storages. The readers of this report should keep in mind that the storage reservoirs are owned and operated for hydropower. From a hydropower perspective there could rightfully be hesitancy at making regulated releases from storage, in excess of hydropower capacity, to minimize the chance of later spillage from storage during a flood period. Hydropower interests might view any flow in excess of hydropower capacity as "wastage" whether it be as a result of spillage from storage during a flood or regulated releases in excess of hydropower capacity.

Upon completion of the system studies, reported herein, a meeting was held on 29 June 1987, with Mr. Corson of the Kennebec Water Power Company, the operator of the three upstream storage reservoirs for downstream owner-clients. The purpose of the meeting was to discuss the studies and inquire of existing operating procedures, criteria and restraints. His plan of operation in general is to maintain a target flow of 3,600 cfs at Madison and then vary up or down from a minimum of about 2,000 cfs to a maximum of about 4,500 cfs, depending on total system storage for the particular month relative to normal storage, as determined from the mean of several years of operation. (Madison is about 25 river miles downstream of Bingham with about 460 square miles of intervening drainage area). He indicated that he had been attempting to draft more in late winter the last few years and relying on spring snowmelt runoff for ample storage refill. He meets at least once a month with the five owner clients regarding operational plans for the next month and he noted that final decisions and recommendations on operation are usually based on varying factors within general guidelines rather than in accordance with any hard rules. Other considerations, though not hard rules or restraints, were that the Fish and Wildlife Service preferred that Moosehead levels not fall below the 10 to 15 October level and that recreational interests would be disturbed if lake levels were significantly below normal during the summer season.

Following development of the seasonal guide curves the results of simulations, using the curves, were compared with actual historic operations. Monthly system operations, both observed and as simulated, for the test period 1955 to 1975 are compared graphically on plates 3 and 4. A computer input-output of an HEC-5 Guide Curve Simulation is appended to this report. Summary plots of average monthly flows at Bingham and system storages, observed and as simulated, are shown on plates 5 and 6. Comparative Bingham flow durations (flow versus percent time) and system storage duration curves are shown on plates 7 and 8.

The bottom line result was that the Bingham flow regime, by guide curve simulation, was remarkably similar to the actual historical flow regime as recorded and published by the U.S. Geological Survey for the Kennebec River at Bingham. On average the simulation indicated about a 20 percent increase in average April flows with a subsequent reduction of about 10 percent for the peak flow month of May (reference plate 5). Simulated flows averaged about 10 percent higher in October and November while about 15 percent lower in February and March. Other months the average flows were nearly identical. Though the flow regime was not markedly different than observed, reservoir storages with the simulation were consistently lower than actual for the historical period (reference plate 6). This is attributed largely to the guide curves calling for increased releases during wetter than normal periods. Simulated storages averaged about 100,000 acre-feet, about 10 percent of total system storage, during the summer season. This 10 percent would represent about 0.7 foot difference in lake level at Moosehead Lake, which might impact recreation. The lower levels of storage resulted in some reduction in (but did not eliminate) spillage during high runoff periods. Most noticeable was the effect during nonspring runoff periods. For example, the December 1973 flood event (water year 1974) resulted from intense rainfall occurring with reservoirs high as a result of an above average runoff summer. The guide curve simulation indicated that the reservoirs would have been drafted sufficiently to store the flood runoff with the maximum monthly control flow at Bingham 6,000 cfs. It is believed that another earlier similar December flood event occurred in 1901.

The monthly guide curve simulations indicated a reduced probability of storage spillage during nonspring refill seasons; however, floods most frequently occur during, or just following, the spring runoff (March 1936, March 1953, April 1979, April 1983 and June 1984) and the guide curve operation was not nearly as effective in eliminating spillage during the spring refill. The guide curves must permit spring storage refill from normal spring runoff; therefore, events that produce abnormally high spring runoff usually result in required spillage at the storage reservoirs and potential for significant contributions to downstream flood flows. Average spring runoff during April and May in the upper Kennebec Basin is about 11 inches or about 46 percent of total annual runoff. Also the April and May runoff can range as high as 17 inches. Total usable storage in the three reservoir system is equivalent to about 10 inches of runoff from their respective watersheds. The total capacity is not available for storage each spring because of the need to retain some water in reserve for unpredictable events such as abnormally low or late spring runoff. Reportedly the lower approximate 1 foot of storage at Moosehead Lake is usually retained both as reserve and due to discharge limitations at the lake outlet.

Because of the high flood sensitivity during the spring season and the limited capability of monthly guide curves to regulate the limited storage for short duration abnormally high runoff events, further exploratory studies were made of potential guide curves for spring refill regulation, using a daily rather than monthly time increment.

d. Spring Refill Guide Curves. The greatest potential for filling and spillage at the upstream storage reservoirs is during the spring refill-runoff period, April, May and June. Greatest spillage contributions to downstream flooding occurs when significant rainfall or snowmelt runoff occurs with the storages initially at, or near, full. Therefore, spring refilling guide curves using a daily time increment, were explored in the interest of minimizing the probability of premature filling of the lakes during the April - May refill period. Any such guide curves would also require that they not increase the probability of not refilling the lakes during drought years. The guide curves were developed by analyzing mean, maximum and minimum lake inflow rates, for the 2-month period April and May, and developing, by trial, total system storage level versus suggested target regulated flow rates at Bingham, to accomplish orderly filling of system storage.

The developed exploratory guide curves are shown on plate 9. In applying the guide curves to experienced high flow events it was found impossible to prevent spillage in most instances; therefore, secondary guidance was explored on project operations during pending flood situations that might modify the peak rate of spillage when spillage was imminent. For example, if storage levels were high and the system was being operated for a target flow at Bingham, in the event of a high runoff occurrence there could be a tendency to cut back releases at the reservoirs, resulting in accelerated filling and later magnified spillage contributing to downstream floods. Secondary guidance was therefore added to the spring refill guide curves that would attempt to modify peak spillage when spillage was imminent. This was accomplished by calling for higher controlled releases from the reservoirs, when storage levels were high, thereby reducing the magnitude of subsequent spillage. The secondary guidance added to the spring guide curves was as follows:

(1) <u>Total System Storage Less Than 900,000 Acre-Feet</u>

(a) <u>Typical Condition</u>. If the guide curve target flow at Bingham is <u>less than 12K</u> and total system storage is less than 900,000 acre-feet (90 percent full) then reservoirs would be operated for the indicated target flow, even to the point of near zero outflow.

(b) <u>Moderate High Storage Early in Season</u>. If the target flow at Bingham is <u>between 12 and 14K</u> and total storage is less than 900,000 acre-feet, reservoirs would be regulated for the 12K target flow but combined outflows would not be made less than 8K.

(c) <u>High Storage Early in Season</u>. If target flow is <u>greater than 14K</u> and storage is less than 900,000 acre-feet, regulation would be for the 14K at Bingham but combined outflows would not be less than 10K.

(2) <u>Total System Storage Greater Than 900,000 Acre-Feet</u>

(a) <u>Typical in Late Spring</u>. If target Q at Bingham is <u>less than 12K</u> but total storage is greater than 900,000 acre-feet then minimum storage outflow would be for target flow or made equal to one-half of the computed rate of inflow to storage, whichever is greater.

(b) <u>Moderate High Storage in Late Spring</u>. If target Q is between 12 and 14K minimum regulated outflow would be 8K or one-half inflow whichever is greater.

(c) <u>High Storage in Late Spring</u>. If target Q is greater than 14K and total storage greater than 900,000 acre-feet, then minimum outflow would be 10K or one-half of inflow, whichever is greater.

The developed spring refill guide curve, shown on plate 9, in concert with the above secondary guidance was tried with the recent spring floods of April 1979, April 1983 and June 1984. As stated earlier, use of the monthly guide curves indicated that there would be no spillage under conditions of a December 1973 flood.

Experienced storage levels at the start of spring refill (1 April) were higher than those resulting with the monthly guide curve simulation; therefore, the spring guide curves were tested under the more severe historical starting (1 April) storage. The results of the three trial floods are summarized in table III. Results indicated that use of the spring guide curves might have reduced peak flow at Bingham from about 40,000 to about 29,000 in April 1979 (27 percent), from about 55,000 to about 47,000 in April 1983 (14 percent) and from about 65,000 to 53,000 cfs (18 percent) in June 1984.

All trials were performed combining all three storages and computing inflow to storage by drainage area ratio with the recorded unregulated Carrabassett riverflows. The unregulated local contribution downstream of the storages above Bingham was also estimated by ratio of drainage area and mean annual runoff with the Carrabassett flows. The resulting regulated outflows from storage using the guide curves were compared with the experienced outflows (reference 1985 report) in determining peak discharge reductions. All trials were also made allowing for no surcharge storage above assumed full system storage capacity of 1 million acre-feet.

Secondly, the spring refill guide curves were tested under the severe droughts of April to May 1957 and 1965 to determine if there would be impact on ability to refill storage sufficient to ensure minimum dependable flow. Since the Monthly Guide Curve Simulation had demonstrated ability to meet the minimum dependable target flow at Bingham, the amount of April to May storage drought refill, using the Daily Spring Refill Guide Curves, was compared with the refill indicated by the monthly simulation. In both test droughts the daily guide curves resulted in April to May refill in excess of that with the monthly curves. However, in both cases the system storage levels were considerably less than experienced. Comparative storage data for the droughts of 1957 and 1965 are shown in table IV. Regarding the developed Guide Curves, the operator of the reservoirs has noted that present hydrologic instrumentation, data transmission

TABLE III

RESERVOIR OPERATION
DURING SPRING REFILL FLOODS
COMPARATIVE DATA

	April 1979	April 1983	June 1984
MOOSEHEAD-FLAGSTAFF			
Peak Discharge			
As Experienced	18,000± cfs	26,000± cfs	34,000 cfs
With Guide Curves	12,000	17,000	27,000
Δ	6,000	9,000	7,000
%	-33%	-34%	-20%
Peak Contribution to Bingham Flood			
As Experienced	11,000± cfs*	16,000± cfs*	32,000 cfs
With Guide Curves	0	8,000	20,000
Δ	11,000	8,000	12,000
%	-100	-50	-37
Δ Stage	−1.5± feet	−1.1± feet	−1.7± feet

* Contribution to First Peak

TABLE IV

RESERVOIR SYSTEM OPERATION
DURING SPRING REFILL DROUGHTS
COMPARATIVE DATA

	April-May 1957	April-May 1965
WATER IN STORAGE (Acre-Feet)		
Starting/Ending		
Experienced	147,310/659,960	209,550/650,290
With Monthly Guide Curve	40,660/360,410	60,000/384,260
With Daily Guide Curve	40,660/441,430	60,000/540,740
CHANGE IN STORAGE (Acre-Feet)		
Experienced	512,650	440,740
With Monthly Guide Curve	319,750	324,260
With Daily Guide Curve	400,770	480,740
MINIMUM FLOW AT BINGHAM (CFS)		
Experienced	1,330*	1,340*
With Monthly Guide Curve	2,000	2,000
With Daily Guide Curve	2,000	2,000

* Minimum experienced daily flow likely effected by regulation at Wyman

and weather forecasts in the basin, during high runoff periods, are inadequate to permit operating for a target flow at a downstream location and releases during high runoff were generally based on storage conditions at the reservoirs. He also noted that the mode of operation at the reservoirs was not conducive for making frequent changes in release rates, particularly any operation calling for night time gate changes where personnel safety could be at risk.

4. FLOOD STORAGE EFFECTIVENESS

This section presents data and discussion on the estimated magnitude of flood stage reductions that might be provided by flood control storage on selected uncontrolled tributaries and central basin intervening local areas. In the earlier 1985 Flood Hydrology study it was concluded that the Sandy and Carrabassett Rivers were large contributors, relative to watershed size, to lower main stem Kennebec River floodflows. For the four floods reviewed, i.e., December 1973, April 1979, April 1983 and June 1984, the contributions from the Sandy and Carrabassett Rivers to peaks on the lower main stem averaged an estimated 30 percent of floodflow. In the more recent 1987 flood the percent contribution from these two streams was even greater (more nearly 40 percent) because of the negligible contribution from the upper basin storage reservoirs.

In the current analysis, the Carrabassett and Sandy River component flood contributions were compared with four other central basin uncontrolled component local watershed areas. Component contributions, in percent of total, to lower main stem floodflows for the six areas are listed in table V along with their respective drainage areas. Also listed are average component contributions to flood stages in feet, which were based on the U.S. Geological Survey stage-discharge rating for the gage at North Sidney. All component contributions were based on the average for the four floods previously referenced, and does not include the latest 1987 flood which would skew the contributions somewhat higher due to the lower upper basin contributions.

Next, the estimated average potential flood stage reduction in feet was computed per 10,000 acre-feet of flood control storage in each of the respective component watersheds. Flood control needs per square mile of watershed were based on a minimum storage capability of 6 inches of runoff which is equivalent to about 318 acre-feet of storage per square mile of watershed controlled. This last step of the analysis provided quantitative information on flood stage reduction per unit storage, and also relative effectiveness of storage among the six component watersheds. For example, the flood stage reduction per unit of storage in the Sandy and Carrabassett Basins was about double that of some of the other component areas. A summary listing of results is presented in table V. No attempt was made to locate potential flood control storage sites in any of the component watersheds and thus no comparative information has been developed on cost per unit of storage in the different areas.

5. SURCHARGE STORAGE

a. General. Surcharge storage in a reservoir is generally defined as that storage volume between the crest of an uncontrolled spillway (or between the normal full pool elevation of a gated spillway with the crest gates in the normal closed position), and the maximum water surface for which the dam was designed to withstand. Maximum design water surface generally equals top of dam elevation minus a design freeboard, and often represents maximum pool levels under spillway design flood conditions. A cursory review of the surcharge storage characteristics of the three storage reservoirs: Brassua, Moosehead and Flagstaff, revealed no opportunity for any significant use of surcharge storage for added flood control regulation.

b. Brassua Lake. This project has a usable storage capacity of about 9.0 billion cubic feet (200,000 acre-feet) between a minimum pool elevation of 1043 and a maximum normal full pool elevation 1074 feet NGVD. With a surface area of about 9,000 acres and a watershed area of 716 square miles, each foot of surcharge over elevation 1074 would represent 9,000 acre-feet, equivalent to only about 0.25 inch of runoff from its watershed. Therefore, it was concluded that several feet of surcharge storage would be needed at Brassua to provide any significant additional flood control storage.

Flows from Brassua are regulated with four 6-foot diameter low level sluices (sill elevation 1034), a gated log sluice (sill elevation 1057), and fifteen 15-foot wide stoplogged sections between elevations 1065 and 1074 feet NGVD. Top elevation of the earth embankment section of the dam is 1081.5 and the concrete nonoverflow section is 1079.5 feet NGVD. In the past the owners have proposed raising the normal full pool at Brassua, by adding stoplogs, from elevation 1074 to 1076, providing about 18,000 additional acre-feet of usable storage; however, this proposal is still pending. With projects having gated spillways an amount of surcharge storage is required above normal full pool to allow time for gate operation and for the establishment of gate operating schedules based on surcharge pool level and rate of

TABLE V

KENNEBEC RIVER BASIN
COMPONENT CONTRIBUTIONS TO FLOODFLOWS
AND
FLOOD STORAGE EFFECTIVENESS

Component	Drainage Area (sq.mi.)	Average % Contribution to Lower Main Stem Floodflows (percent)	Average Flood Stage Contribution to Lower Main Stem Floods (feet)	Flood Stage Reduction per 10,000 Acre-Feet of Flood Storage* (feet)
Kennebec River Local Above Forks	322	8.76	1.7	0.16
Dead River Local	358	5.55	1.1	0.097
Forks to Bingham Local	251	8.33	1.6	0.20
Carrabassett River	354	14.31	2.7	0.24
Sandy River	514	16.45	3.1	0.19
Sandy to Waterville Local	538	9.18	1.8	0.10

* Flood storage based on minimum of 6 inches (318 acre-feet) per square mile of watershed controlled

rise. It was concluded that there was no opportunity for surcharge storage regulation at Brassua Lake, beyond the incidental flood control provided by existing gate regulation, particularly if the normal full pool is eventually raised 2 feet to elevation 1076 feet NGVD.

c. Moosehead Lake. Moosehead Lake has a gross usable storage capacity of about 544,000 acre-feet between elevations 1021.3 and normal full pool elevation 1029.0 feet NGVD, with discharge limitations from the lower foot of storage. With a surface area of 74,000 acres and a total drainage area of 1,268 square miles, a foot of surcharge storage represents 74,000 acre-feet of storage equivalent to 1.1 inches of runoff from its total watershed, or 2.5 inches of storage from the 558 square miles of net drainage area below Brassua. Therefore, it is concluded that a small increment of depth in Moosehead represents considerable flood control storage potential.

Moosehead has two regulating outlet locations: East and West; however, most flood regulation is done at the East Outlet. This facility is equipped with two 20-foot wide tainter gates, two 18-foot wide gated log sluices, and 17 other vertical gates, of varying types and widths, making up a total gated overflow width of about 320 feet with all gate sills at about elevation 1018.5 feet NGVD.

Historically, project operation has maintained surcharge storage levels to not over 1029.4 feet NGVD, or about 0.4 foot above normal full pool. The top of dam elevation at Moosehead is 1032.5 feet NGVD providing a minimum of only about 3 feet of freeboard above maximum historic lake levels.

It was concluded that project restraints severely limit using any significant depth of surcharge at this project, however, the appreciable amount of storage per unit depth emphasizes the importance of project gate operation and available storage utilization for overall effective operation during flood periods.

d. Flagstaff Lake. Flagstaff Lake has a usable storage capacity of about 276,000 acre-feet between elevation 1111 feet NGVD and normal full pool elevation 1146 feet NGVD. With a full pool surface area of 17,930 acres and a watershed area of 516 square miles, a foot of surcharge storage represents nearly 18,000 acre-feet of storage equivalent to about 0.65 inch of runoff. Reportedly, maximum surcharge storage utilized at the project during a flood period has been about 0.9 foot.

Flagstaff flows are regulated by two 7-foot low level sluices (invert elevation 1110) and five 20-foot wide tainter gates, sill elevation 1134.0 feet NGVD. The project has a 450-foot long spillway, crest elevation 1144 feet NGVD, equipped with 2 feet of flashboards resulting in a normal full pool level of 1146 feet NGVD. It was concluded that when pool levels exceed normal full pool the project quite rapidly becomes self-regulating and no appreciable surcharge storage could be utilized for added flood regulation without major modifications to the project's spillway.

The top of the earth embankment and the concrete nonoverflow section at Flagstaff are at elevations 1156 and 1153 feet NGVD, respectively.

6. MARCH/APRIL 1987 FLOOD

The most recent Kennebec flood was the result of high volume rainfall occurring on the last day of March and first day of April. The rainfall was produced by waves of low pressure moving northeasterly along a cold front creeping across New England from the west. The cold front and rainfall followed several days of daytime temperatures in the sixties. The high volume rainfall occurring under above average ripe snowpack conditions resulted in record runoff over much of the Kennebec Basin. Rainfall totals varied considerably over the basin with maximum amounts recorded in the central part of the basin in the region of Wyman Dam (Bingham). Maximums of 6 to 7 inches were experienced at the storm center with more nearly 3 inches in the regions of the upper headwater reservoirs and 4 to 5 inches in the lower basin. The resulting runoff produced new floods of record in the Kennebec Basin generally from the mouth of the Carrabassett tributary downstream throughout the middle and lower basin. Peak flows on the lower main stem Kennebec and tributaries: Sandy, Carrabassett and Sebasticook Rivers ranged from 20 to 30 percent greater than the earlier greatest flood of March 1936. Though coincident snowpack conditions during the recent rainfall produced appreciable snowmelt runoff, it was fortunate that ice had generally gone out of the rivers prior to the event, (a factor contributing to damages in 1936) and that the three upstream storage reservoirs were in a prespring runoff, drawn down state. Therefore, they completely controlled runoff from their contributing watersheds.

Computed inflows, outflows, and changes in storage at Moosehead and Flagstaff Reservoirs are shown graphically on plates 10 and 11. This event dramatically demonstrated, as was stated in the earlier 1985 report, that there is potential for major flooding on the Kennebec from watershed runoff downstream of the three large upper basin storage reservoirs. On the other hand, had the recent event occurred under conditions of near full reservoirs, such as in June 1984, it is estimated that flows in the lower Kennebec, in the vicinity of the North Sidney gage, could have been in the order of 20 percent greater, with resulting flood stages in the order of 4 feet higher. Fortunately, having full snowpack conditions under full reservoir conditions would be quite unlikely.

Because of the reservoirs the upper basin above Bingham, representing 50 percent of the watershed above Augusta, contributed only about 25 percent of the peak flow at Augusta. By comparison the intervening 1513 square miles of watershed between Bingham and Waterville, including the Sandy and Carrabassett tributaries, representing only about 30 percent of the watershed at Augusta, contributed about 60 percent of the peak floodflow at Augusta.

Flood hydrographs and component contributions to peak flows, estimated and recorded, are shown graphically on plates 10 through 12. It is noted that much of the 1987 flood analysis was based on provisional postflood USGS data subject to revision prior to publication. Also an indepth, more authoritative hydrologic report, is being prepared by the Maine U.S. Geological Survey and will be available for future reference.

In analyzing the 1987 flood, the local contribution hydrograph between the Forks and Bingham gages was computed by lagging the Forks hydrograph 1 hour and subtracting from the Bingham data. Component contributions at North Sidney were computed by lag/averaging the Bingham hydrograph 16/7 hours and lagging the Carrabassett and Sandy River hydrographs 12 hours.

7. SUMMARY

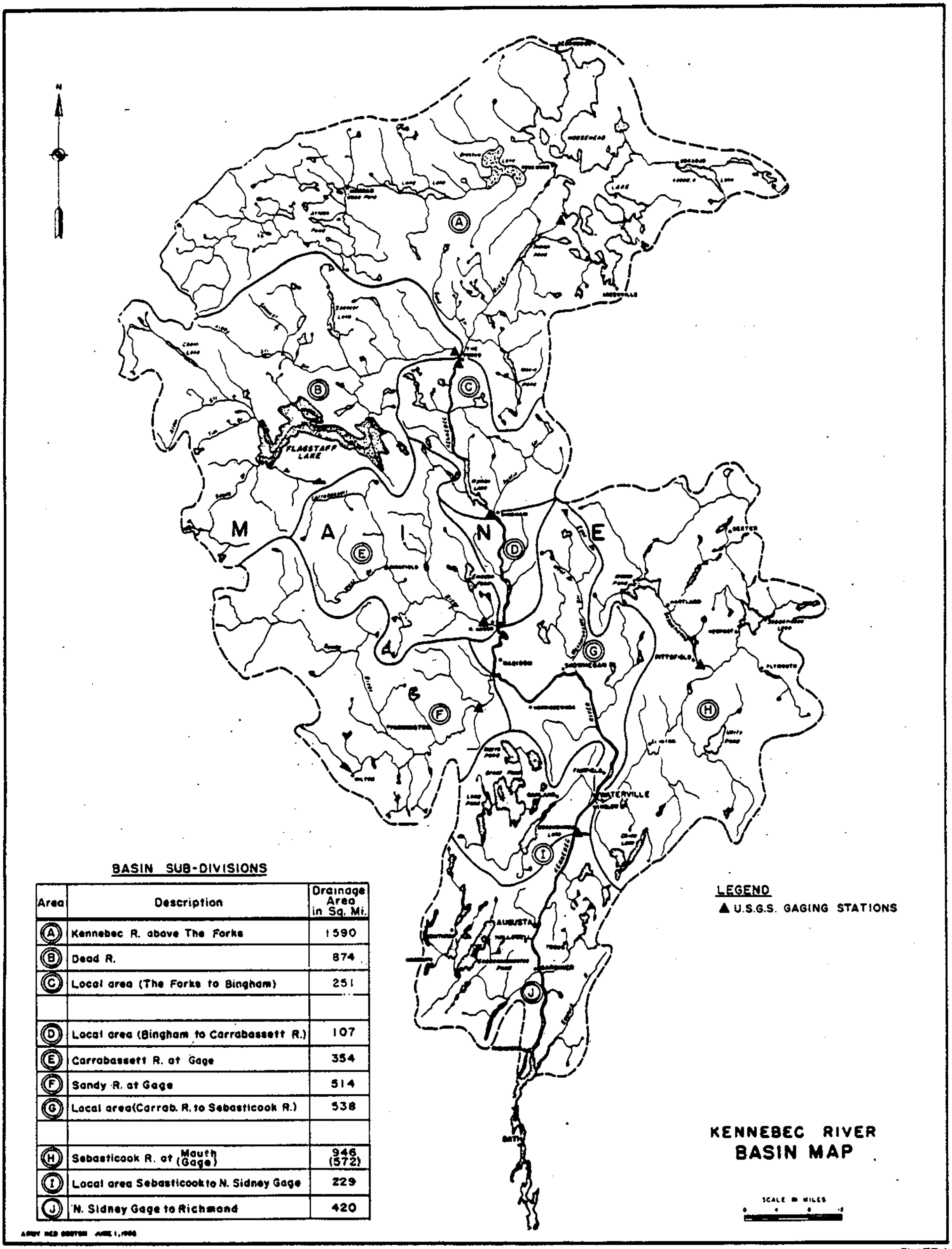
All season reservoir regulation guide curves were developed by trial through multiyear sequential hydrologic system simulations. The objective was to maximize reservoir storage availability for incidental flood control while not adversely impacting hydropower capability. Simulations, using the developed guide curves, indicated that they would result in little change in downstream flow regime but provide significantly greater reservoir storage availability. Storage capacity of 570,000 acre-feet, equivalent to 6 inches of flood runoff, would be available about 65 percent of the time as compared with less than 40 percent under actual operations. Guide curve operation would likely minimize spillage during nonspring refill floods such as the December 1973 event, but would not eliminate all spillage during critical spring refill season floods such as April 1983 and June 1984. Because spring refill is the most critical flood season, spring season (April and May) guide curves were explored that might aid orderly spring refill, minimize potential for premature spring refill, while not impacting storage capability during drought years.

In applying the guide curves to past flood events it was found impossible in most instances to prevent spillage. Average April to May runoff in the upper Kennebec is about 11 inches, or equivalent to total usable reservoir storage; therefore, when abnormal spring runoff, as high as 17 inches, occurs then spillage is inevitable. Therefore, secondary guidance was added to the guide curves in an effort to modify peak rates of spillage when spillage was eminent. Applying the guidance to the experienced April 1979, April 1983 and June 1984 flood events indicated potential reductions of about 30 percent in peak rates of spillage.

Cursory analyses were made of the relative effectiveness of flood control storage in various presently uncontrolled subwatersheds upstream of Waterville, Maine. Resulting average main stem flood stage reduction per 100,000 acre-feet of storage varied from about 1.0 to 2.5 feet for different subwatersheds with maximum effectiveness indicated for the Carrabassett tributary.

A review of surcharge storage characteristics at the three storage reservoirs: Brassua, Moosehead and Flagstaff, revealed no opportunity for any significant added use of surcharge storage for flood control. An amount of surcharge storage is required for gate operation and for the establishment of gate operation schedules, which result in some incidental modification between peak inflow and outflow. The large amount of surcharge storage, per unit depth at these large lake areas, emphasizes the importance of gate operating schedules and available storage utilization for effective project operation during floods.

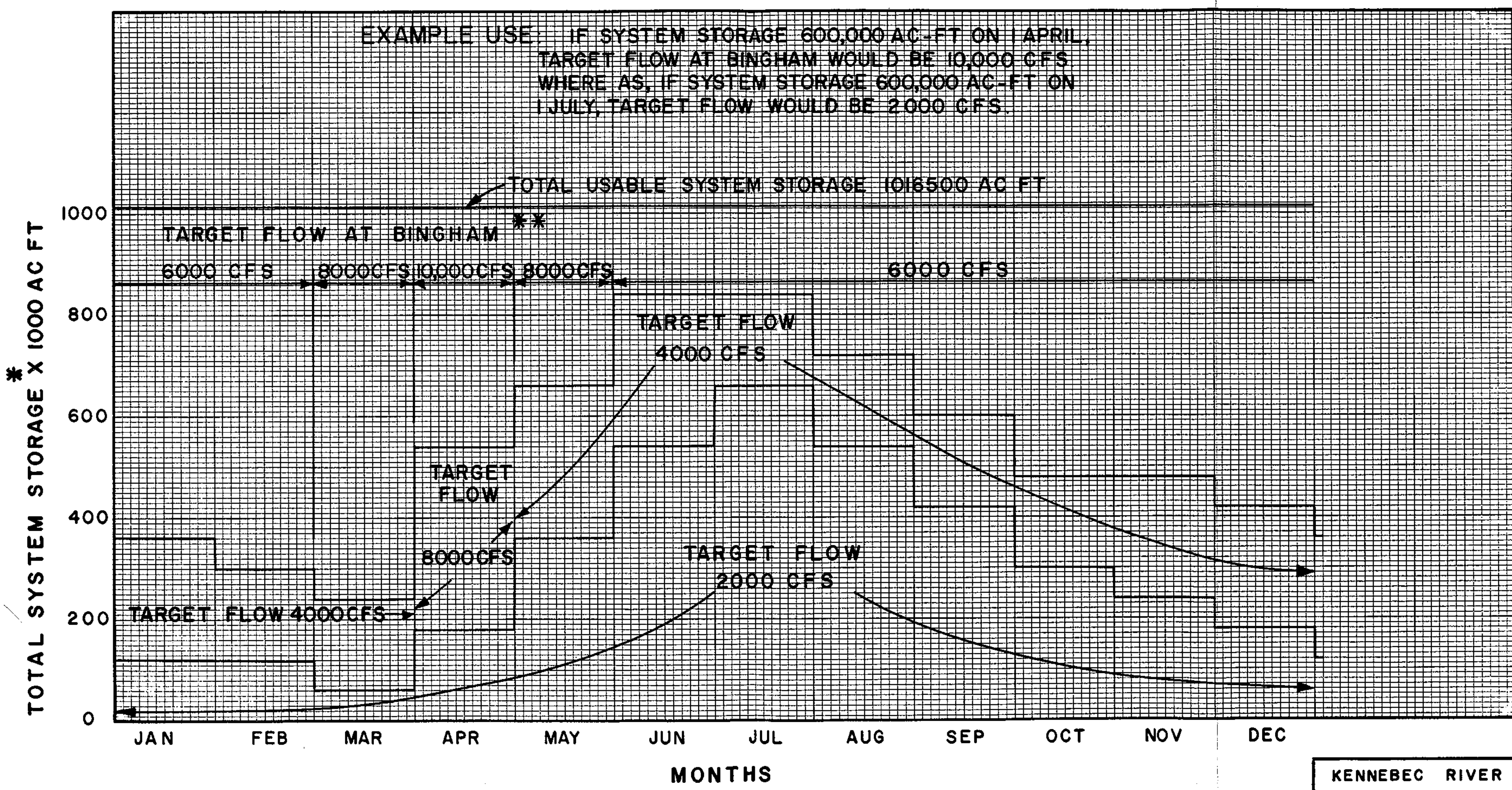
The most recent major Kennebec River flood of March/April 1987 was analyzed, and component contributions determined, using provisional streamflow and rainfall records. This was a new flood of record generally throughout the mid to lower Kennebec Basin and, with the upper basin reservoirs completely controlling the runoff from their contributing watersheds, dramatically demonstrated the flood producing potential of runoff from the uncontrolled downstream watersheds.



BASIN SUB-DIVISIONS

Area	Description	Drainage Area in Sq. Mi.
A	Kennebec R. above The Forks	1590
B	Dead R.	874
C	Local area (The Forks to Bingham)	251
D	Local area (Bingham to Carrabassett R.)	107
E	Carrabassett R. at Gage	354
F	Sandy R. at Gage	514
G	Local area(Carrab. R. to Sebasticook R.)	538
H	Sebasticook R. at Mouth (Gage)	946 (572)
I	Local area Sebasticook to N. Sidney Gage	229
J	N. Sidney Gage to Richmond	420

PLATE I



* SYSTEM STORAGE REFERS TO THE THREE LAKES BRASSUA, MOOSEHEAD AND FLAGSTAFF

** TARGET FLOWS ARE ON KENNEBEC RIVER AT BINGHAM

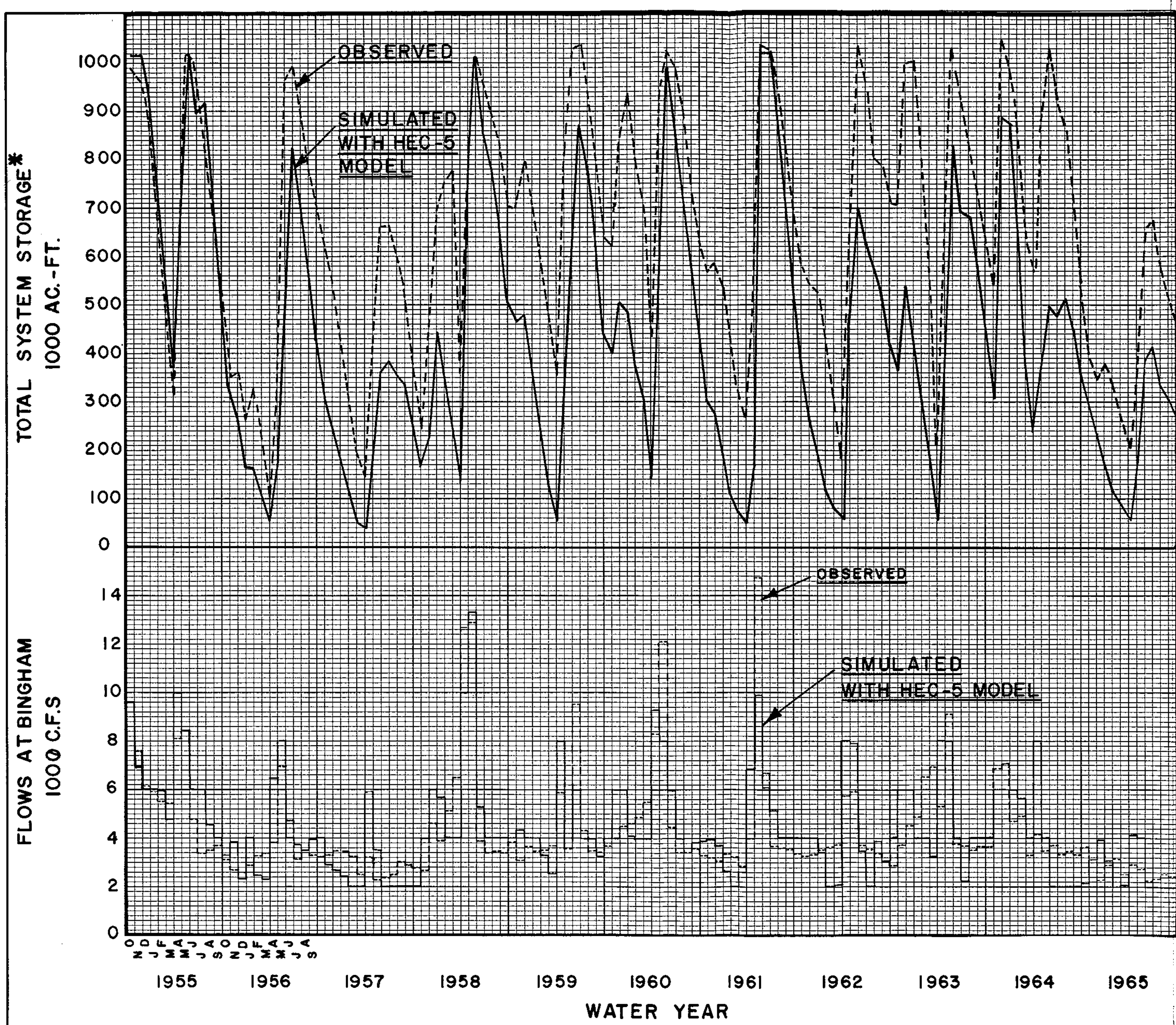
KENNEBEC RIVER BASIN

MONTHLY GUIDE CURVES

FOR LAKE REGULATION

HES JULY 1987

PLATE 2



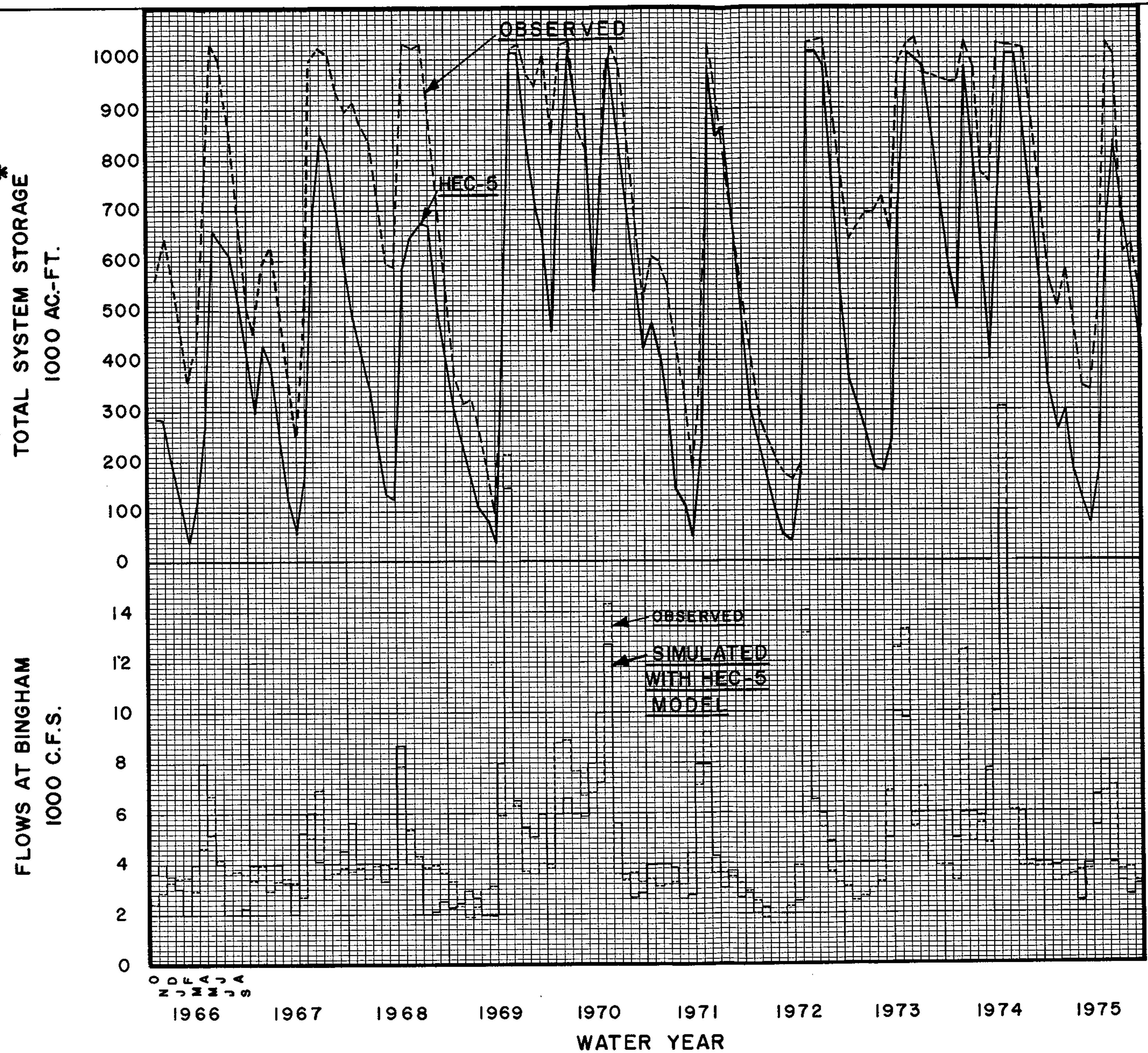
* SYSTEM STORAGE REFERS TO THE THREE LAKES: BRASSUA, MOOSEHEAD & FLAGSTAFF.

KENNEBEC RIVER BASIN

TOTAL SYSTEM STORAGE AND FLOWS AT BINGHAM OBSERVED & SIMULATED

HES JULY 1987

PLATE 3



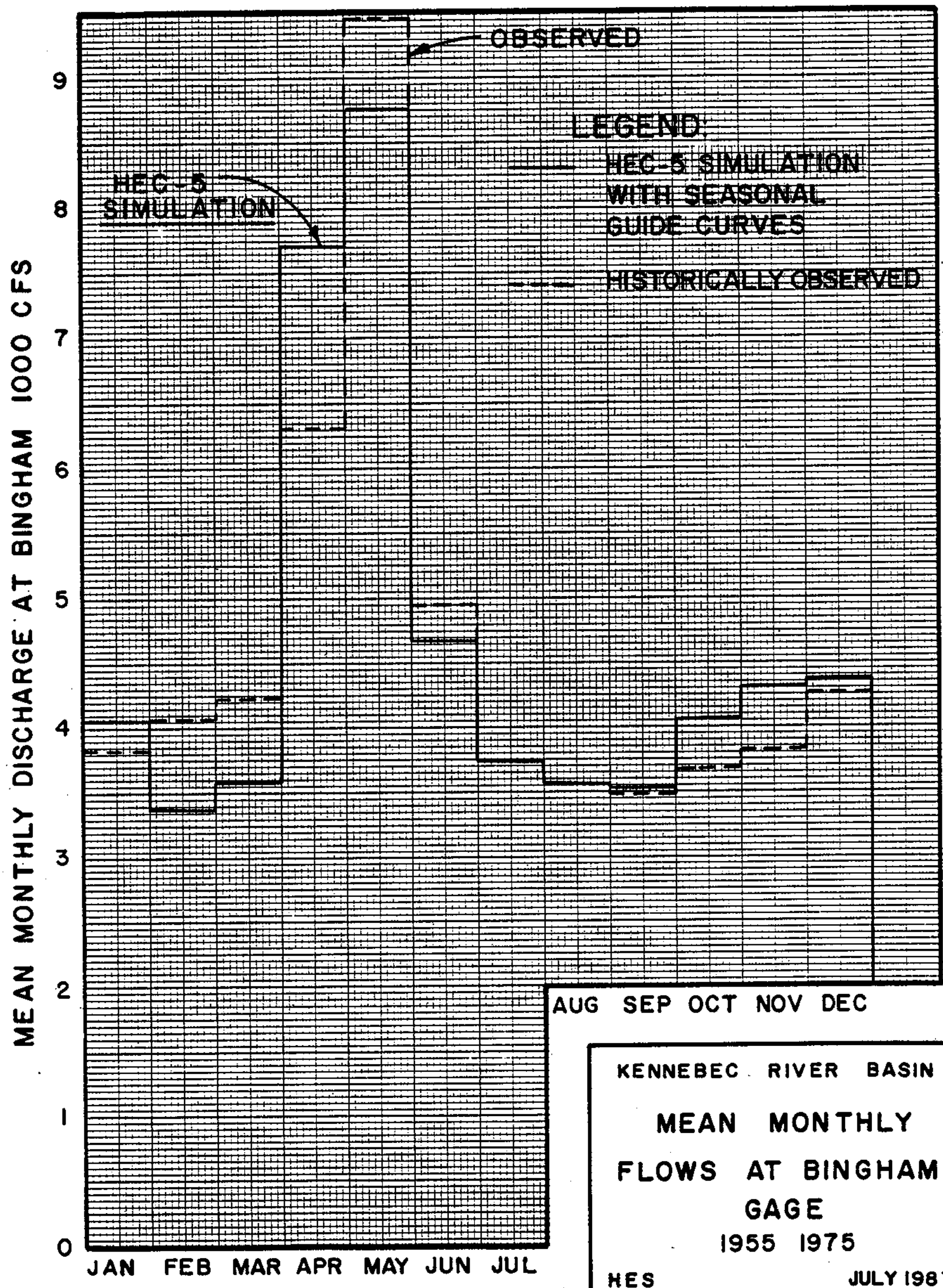
* SYSTEM STORAGE REFERS TO THE THREE LAKES: BRASSUA, MOOSEHEAD & FLAGSTAFF.

KENNEBEC RIVER BASIN

TOTAL SYSTEM STORAGE AND FLOWS AT BINGHAM OBSERVED & SIMULATED

HES JULY 1987

PLATE 4



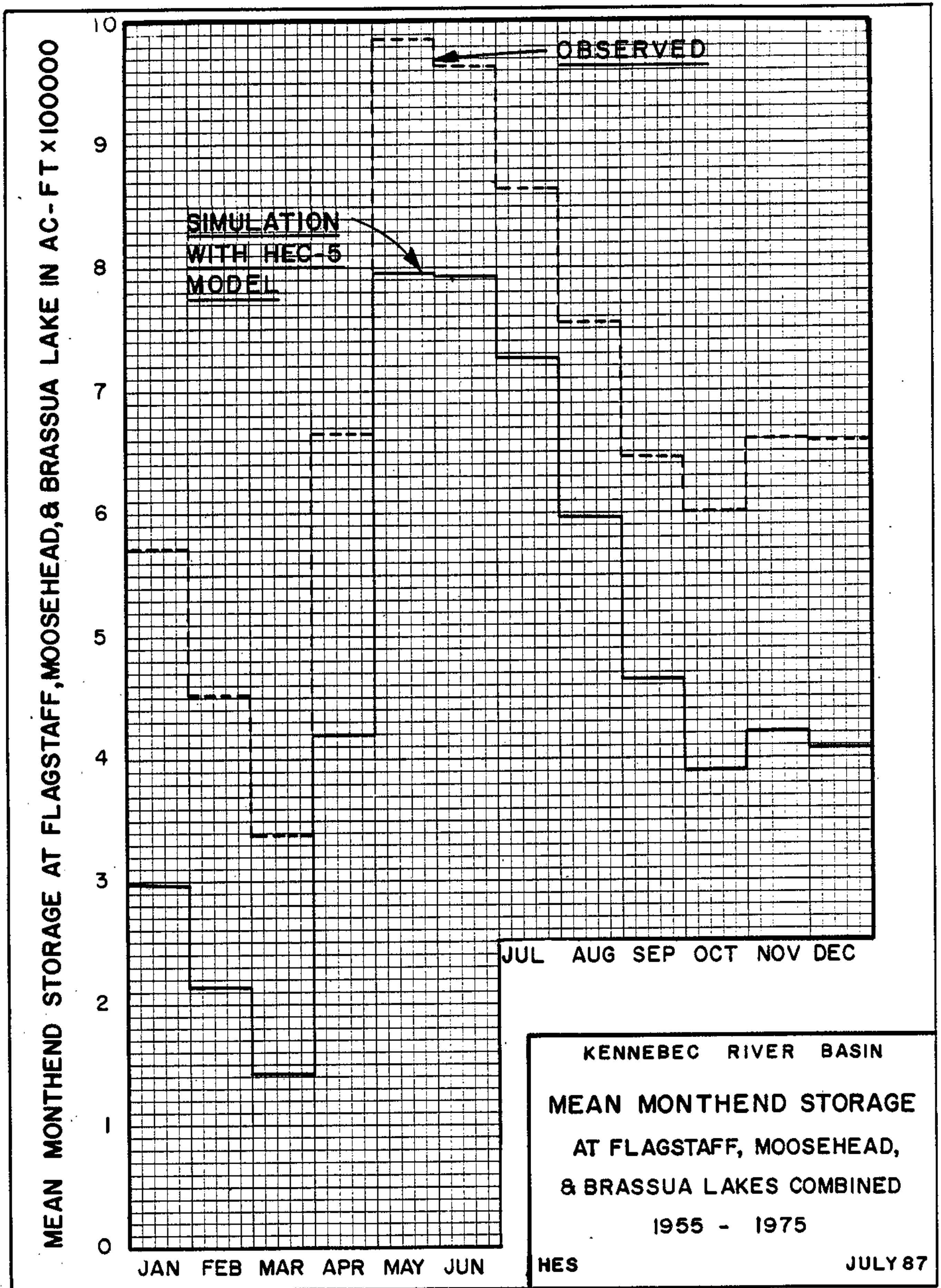
KENNEBEC RIVER BASIN

MEAN MONTHLY FLOWS AT BINGHAM GAGE

1955 1975

HES JULY 1987

PLATE 5



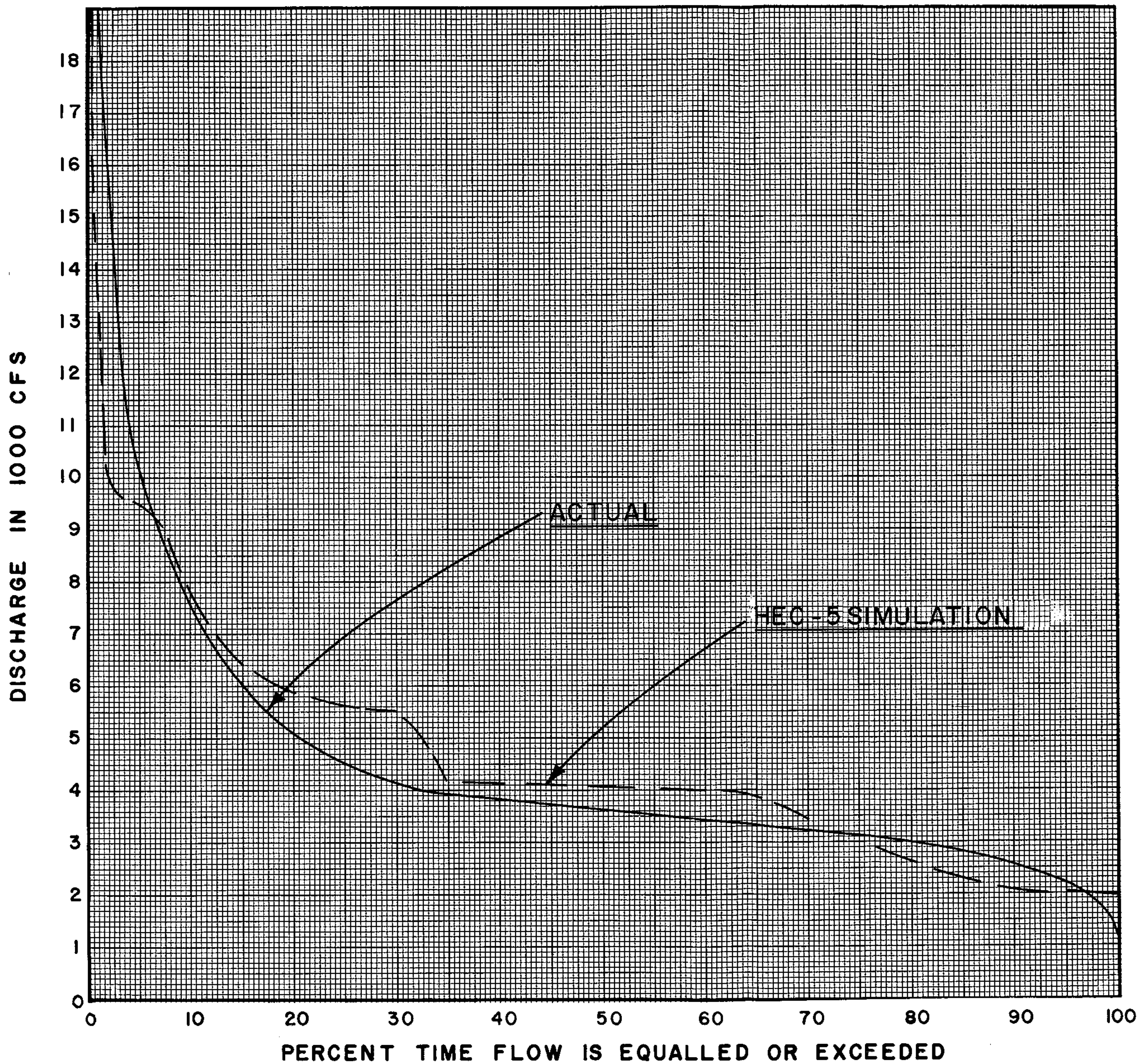
KENNEBEC RIVER BASIN

MEAN MONTHEND STORAGE AT FLAGSTAFF, MOOSEHEAD, & BRASSUA LAKES COMBINED

1955 - 1975

HES JULY 87

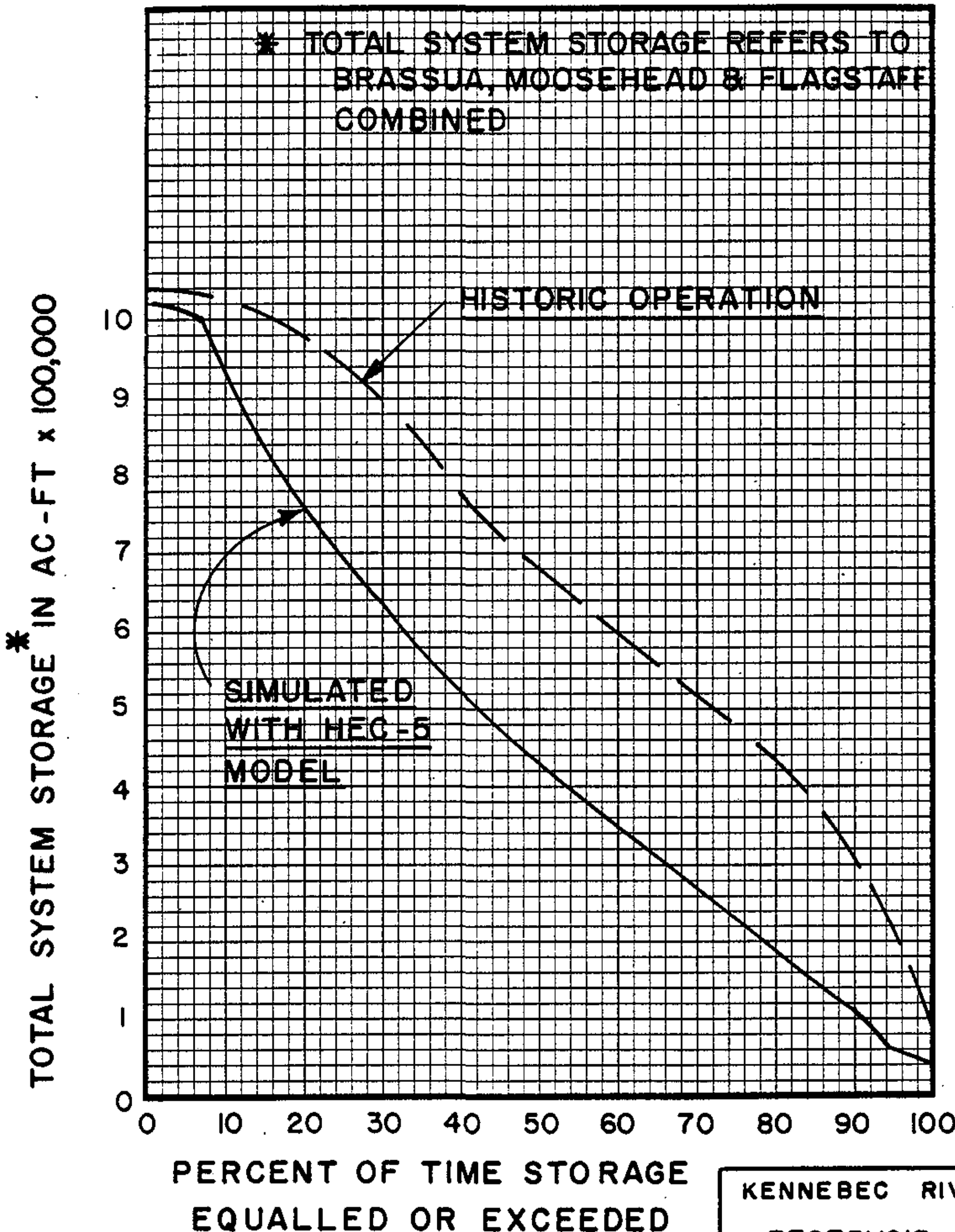
PLATE 6



NOTES:
D.A. = 2715 SQ. MI.
PERIOD OF ANALYSIS
1955 - 1975

KENNEBEC RIVER BASIN
FLOW DURATION CURVES AT BINGHAM
HES JULY 1987

PLATE 7

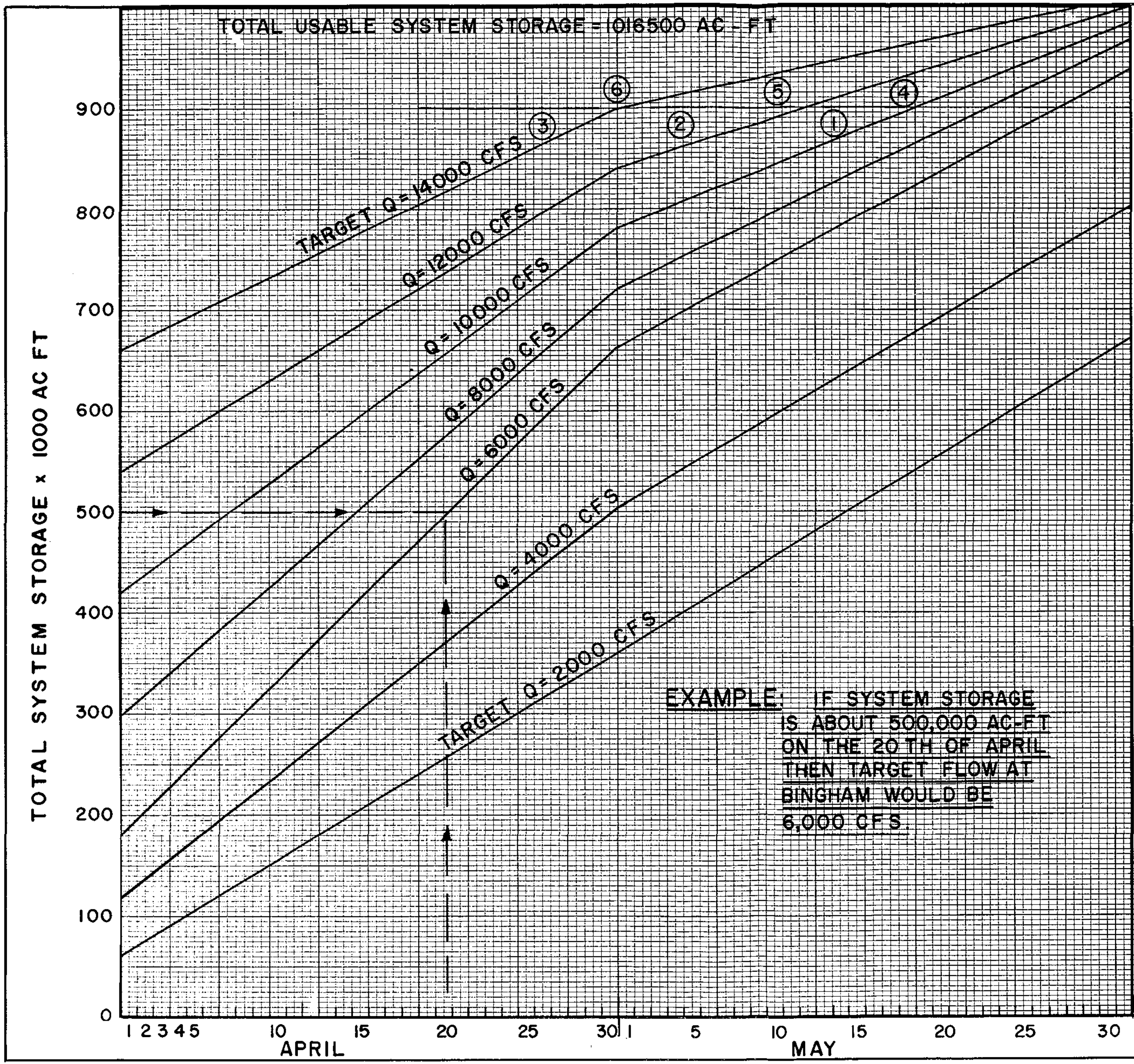


KENNEBEC RIVER BASIN
RESERVOIR SYSTEM

STORAGE-DURATION
CURVES

1955-75 TEST PERIOD

PLATE 8



NOTES:

STOR. < 900,000

1. TARGET "Q" < 12,000
   NO MIN. RELEASE RATE
2. TARGET "Q" 12 - 14 K
   MIN. RELEASE => 8 K
3. TARGET "Q" > 14,000
   MIN. RELEASE => 10 K

STOR. > 900,000

4. TARGET "Q" < 12,000
   MIN. RELEASE = > 1/2 IN FLOW
5. TARGET "Q" 12 - 14 K
   MIN. RELEASE => 1/2 IN FLOW OR 8 K
6. TARGET "Q" > 14 K
   MIN. RELEASE => 1/2 IN FLOW OR 10 K

LEGEND

< LESS THAN
> GREATER THAN
=> NOT LESS THAN

KENNEBEC RIVER BASIN

RESERVOIR STORAGE SPRING REFILL GUIDE CURVES

HES JULY 1987

PLATE 9

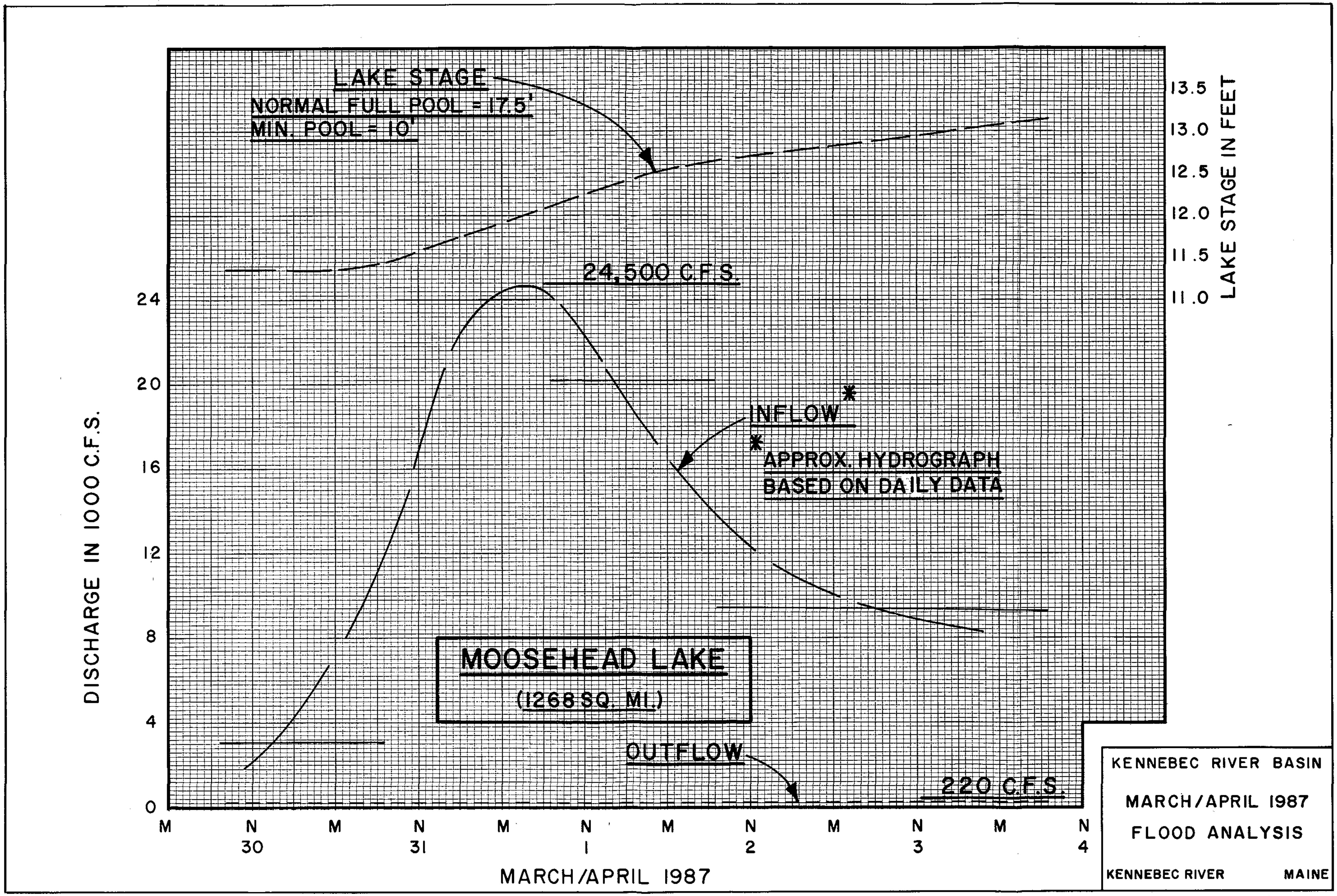
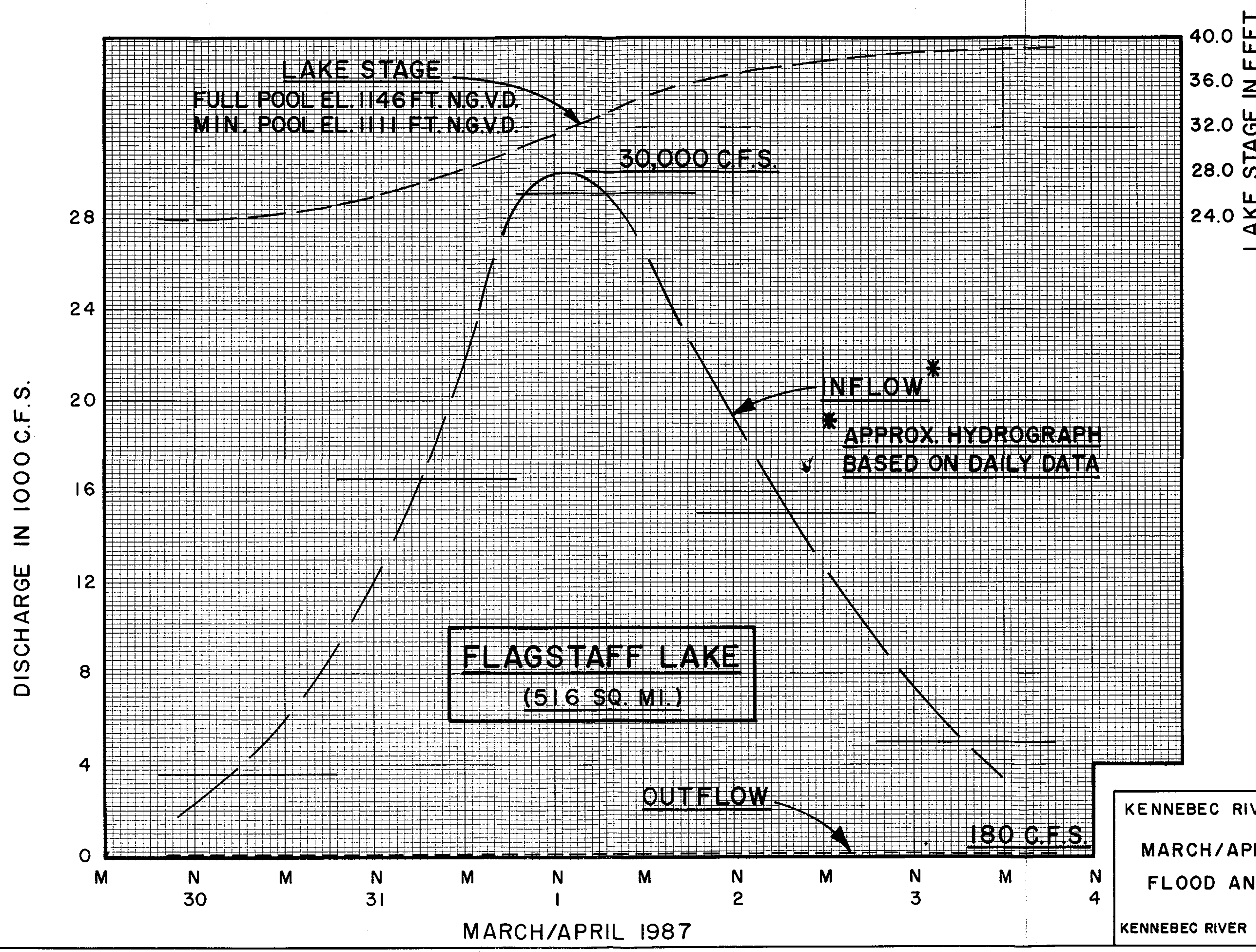

LAKE STAGE
NORMAL FULL POOL = 17.5'
MIN. POOL = 10'
24,500 C.F.S.
INFLOW *
* APPROX. HYDROGRAPH BASED ON DAILY DATA
MOOSEHEAD LAKE
(1268 SQ. MI.)
OUTFLOW
220 C.F.S.
DISCHARGE IN 1000 C.F.S.
0
4
8
12
16
20
24
LAKE STAGE IN FEET
11.0
11.5
12.0
12.5
13.0
13.5
M N M N M N M N M N M N
30 31 1 2 3 4
MARCH/APRIL 1987
KENNEBEC RIVER BASIN
MARCH/APRIL 1987
FLOOD ANALYSIS
KENNEBEC RIVER
MAINE

PLATE 10

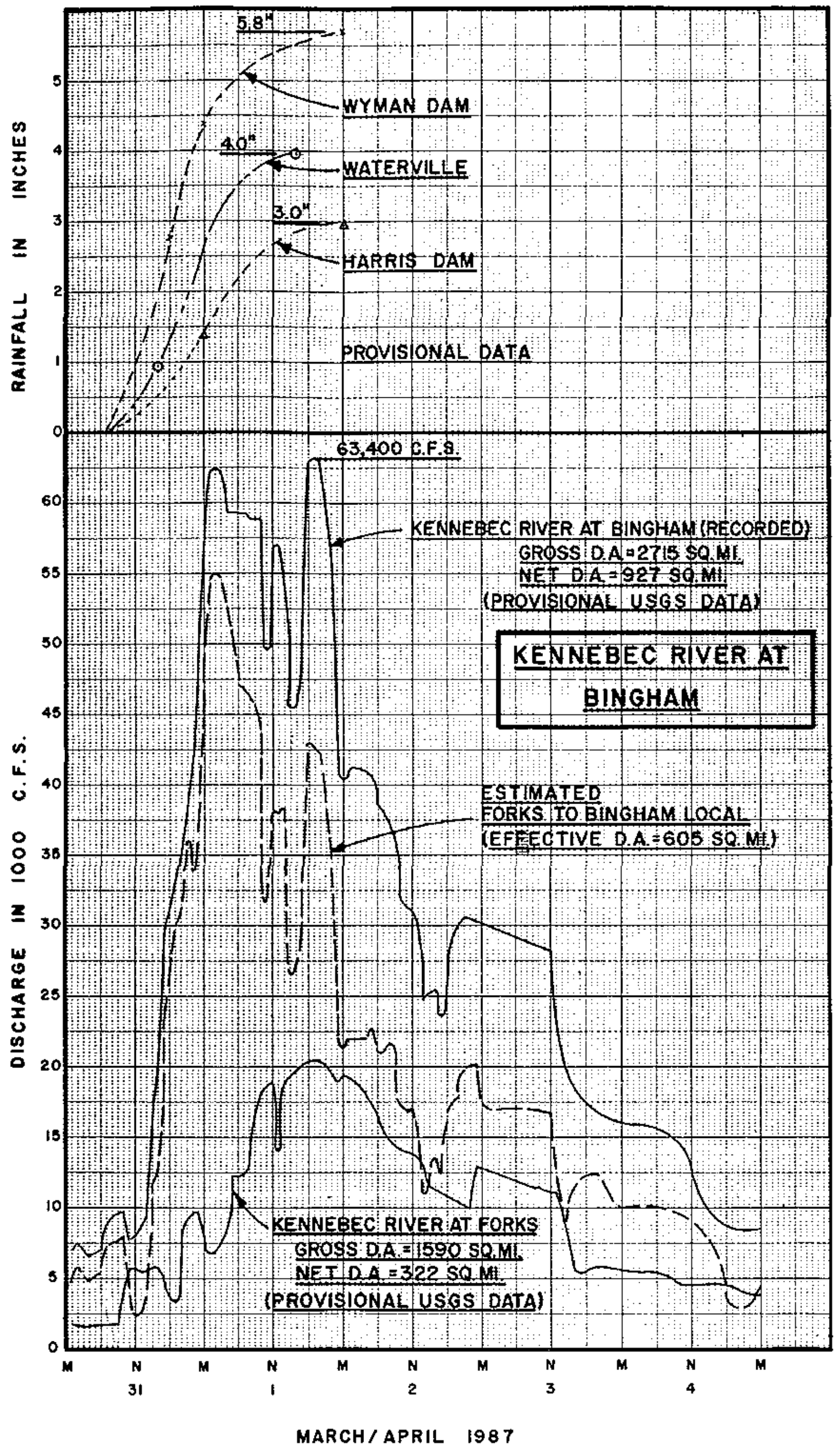


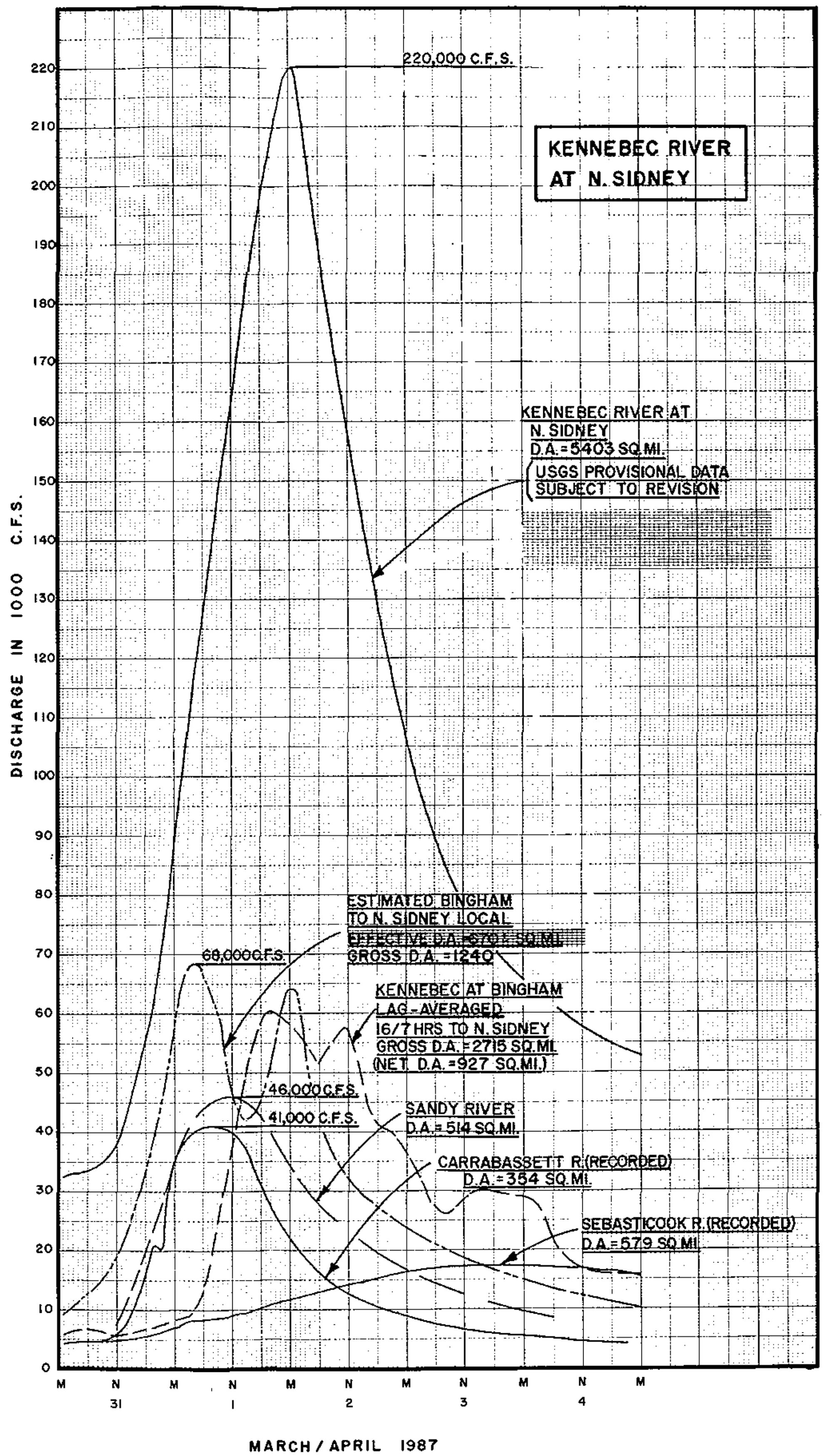
KENNEBEC RIVER BASIN

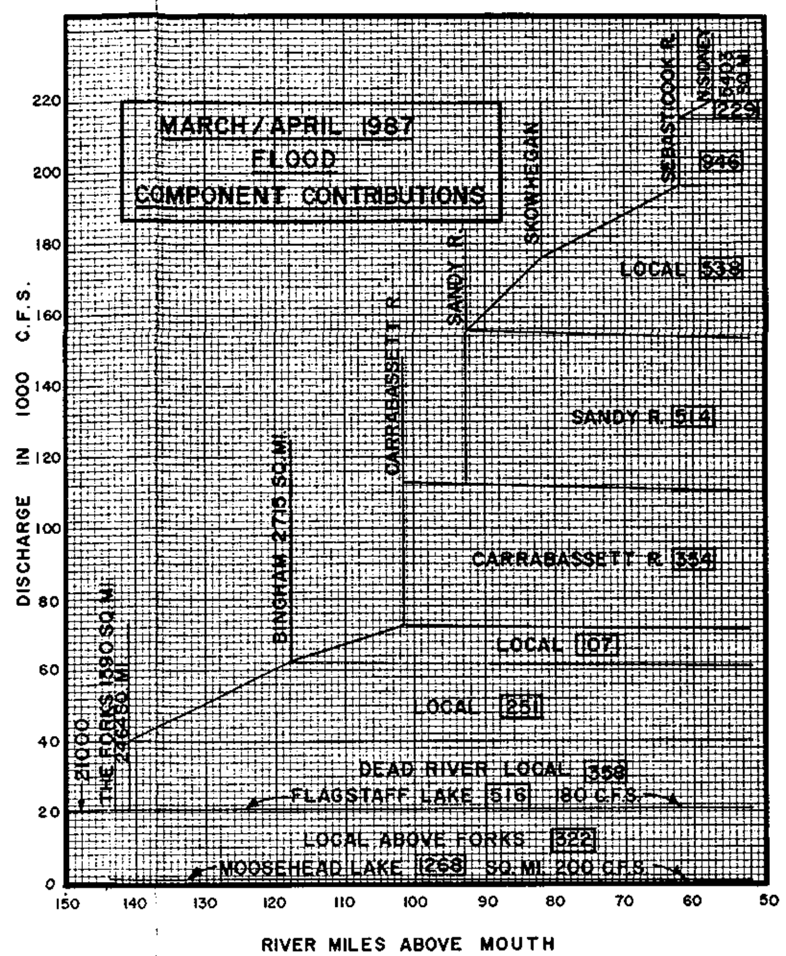
MARCH/APRIL 1987
FLOOD ANALYSIS

KENNEBEC RIVER MAINE

PLATE 11







DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

KENNEBEC RIVER BASIN

FLOOD ANALYSIS

MARCH - APRIL 1987

A P P E N D I X

HEC-5 COMPUTER INPUT-OUTPUT

BRASSUA, MOOSEHEAD & FLAGSTAFF SYSTEM SIMULATION USING SEASONAL GUIDE CURVES

SEPTEMBER 1987

1

5 SIMULATION OF FLOOD CONTROL
AND CONSERVATION SYSTEMS

APRIL 1982 VERSION   (UPDATED 14 FEB 83)

MAX DIMENSION LIMITS ARE CURRENTLY SET AT   35 RESERVOIRS AND   55 CONTROL POINTS

*INPUT LISTING FROM HEC5A

TO SUPPRESS LISTING, INSERT NCLIST CARD INTO INPUT DECK AT DESIRED POINT

```
T1 KENNEEEC RIVER BASIN STUDY
T2 BRASSUA MOOSEHEAD & FLAGGSTAFF OPERATING
T3 FOR FRM YIELD AT BINGHAM
J1       0        10         6         5         6         2         0        10
J2                                    16
J3       4
JZ    1.09      1.11      1.10      2.09      2.11      2.10      3.11      3.10      4.24      4.04

RL       1    196500         0     47800    123500    160000    196500    196500
RL       1         1         0         0         0         0         0         0         0         0
RL                                               0         0         0         0         0         0
RL       2         1         0         0     45000     35000     15000      7000      7000      7000
RL                                           15000     60000    110000    140000    110000     80000
RL       3         1         0         0     57000     49000     34000     22000     20000     15000
RL                                           42000     88000    133000    147000    117000     87000
RL       4         1         0         0     76000     72000     57000     41000     35000    225000
RL                                           76000    114000    159000    166000    136000    106000
RL       5         1         0         0     95000     95000     80000     60000     50000     30000
RL                                          110000    140000    185000    185000    155000    125000
RL       6         1         0         0    196500    196500    196500    196500    196500    196500
RL                                          196500    196500    196500    196500    196500    196500
RO       1         2
RS       4         0      7270    120800    196500
RQ       4      8000      8000      8000      8000
RE       4      1030      1040      1050      1073

CP       1      2000       142       142
ID BRASSUA
C1       1       .26
RT       1         2

RL       2    544000         0     70800    206000    408800    544000    544000
RL       1         2         0         0         0         0         0         0         0         0
RL                                               0         0         0         0         0         0
RL       2         2         0              170000    135000    110000     75000     75000     35000
RL                                          110000    200000    285000    345000    285000    225000
RL       3         2         0         0    187000    173000    143000    118000     99000     67000
RL                                          163000    251000    341000    367000    337000    247000
RL       4         2         0         0    221000    214000    184000    159000    132000    101000
RL                                          224000    298000    388000    401000    341000    281000
RL       5         2         0         0    255000    255000    225000    200000    165000    135000
RL                                          285000    345000    435000    435000    375000    315000
RL       6         2         0         0    544000    544000    544000    544000    544000    544000
RL                                          544000    544000    544000    544000    544000    544000
RO       1         4
RS       4         0     70800    408800    544000
RQ       4     20000     20000     20000     20000
```

```
RE      4     1000      1010      1920      1029

CP      2     8000       250       250
IDMOOSEHEAD
C1      2      .21
RI      2        4

RL      3   276000         0     82100    137500    220600    276000    276000
RL      1        3         0         0         0         0         0         0         0         0
RL                                             0         0         0         0         0         0
RL      2        3         0         0     85000     70000     55000     38000     38000     18000
RL                                         55000    100000    145000    175000    145000    115000
RL      3        3         0         0    102000     92000     77000     62000     53000     37000
RL                                         85000    125000    170000    192000    162000    132000
RL      4        3         0         0    116000    110000     96000     81000     69000     56000
RL                                        117000    150000    195000    206000    176000    146000
RL      5        3         0         0    130000    130000    115000    100000     85000     75000
RL                                        145000    175000    220000    220000    190000    160000
RL      6        3         0         0    276000    276000    276000    276000    276000    276000
RL                                        276000    276000    276000    276000    276000    276000
RO      1        4
RS      4        0     82100    220600    276000
RQ      4     5000      5000      5000      5000
RE      4     1080      1100      1120      1144

CP      3     8000       104       104
IDFLAGGSTAFF
C1      3      .19
RI      3        4

CP      4     8000      4000      2000
IDBINGHAM GAGE
C1      4      .34
RI      4
CC     12     6000      6000      6000      6000      6000      8000     10000      8000      6000
CC   6000     6000      6000
QM   4000     4000      4000      4000      4000      4000      8000      4000      4000      4000
QM   4000     4000
ED
9F      0      412         0      051060100         0       720
ZW A=KENNEBEC F=BASE
```

IN		1JUNE1951	2123	2880	1331	2208	1477	7849	4452	2366
IN	2114	1160	14005	11091	6123	152	114	226	870	1034
IN	2992	2504	2442	10660	20040	9092	1978	1254	641	695
IN	1931	5139	6424	1801	2102	3382	17070	13520	8536	3838
IN	4889	9770	9598	6947	4745	2295	2426	2365	16370	12730
IN	3999	6254	1713	180	196	2614	903	3935	1581	1279
IN	8568	17170	5227	1887	1010	1806	2020	1891	1680	1357
IN	868	1846	8286	6449	2389	1571	1630	626	576	5069
IN	9464	4502	1978	2139	20530	17550	2525	2798	2211	1280
IN	3338	4406	2029	2069	1315	1328	14110	7462	10040	2413
IN	1393	295	3392	7821	5591	2399	2743	1490	17300	13900
IN	3938	1686	809	1687	1937	3518	2387	1452	1290	2335
IN	9188	23440	6160	2485	1037	1761	1216	2328	2893	2151
IN	1307	1695	15009	11609	2148	1160	3139	1201	3134	8843
IN	4336	1575	1824	1453	12910	15820	1696	2110	2100	2005
IN	1754	15800	5755	2003	1050	1943	10500	5752	1635	2646
IN	923	552	1012	2179	2928	1980	1508	1611	6131	7322
IN	2486	858	1321	1401	3900	4085	1955	1743	722	5316
IN	10709	11320	3644	1442	664	583	2069	6203	3219	1789
IN	1048	899	7293	13850	7304	3412	2274	2752	3677	2810
IN	2950	2008	1841	3823	16290	5236	4421	1961	63	483
IN	344	1419	1959	1566	1512	1269	13120	29860	6548	2808
IN	3002	4713	1005	12650	9176	3989	5871	2244	14420	16270
IN	2859	1235	172	722	4857	2902	2408	1247	1969	1782
IN	11110	20190	2040	716	1250	518	832	884	1218	585
IN	1113	1867	4865	27670	6590	5422	1177	291	1289	2950
IN	3284	2911	3840	6061	18840	13780	5685	5821	3922	3691
IN	3803	3553	13920	3446	1829	4528	16100	22070	6011	3847
IN	1565	1087	640	2458	4650	1948	1382	3469	8411	16330
IN	6454	1083	257	1000	2410	3175	2800	2000	3420	8120
IN	19050	10900	2190	7740	7080	1790	6730	4110	3610	1089
IN	800	24400	14200	3510	6800	1510	2410	4059	16400	6890
IN	3420	13200	3243	2830	15000	13600	4000	1190	610	410
IN	605	580	373	2090	1260	12000	17400	11800	4900	1390
IN	960	1330	3383	4220	2600	1100	500	2220	11500	4950
IN	1370	1050	1003	820	2470	2710	2730	830	8490	2580
IN	5050	4700	3690	1770	2000	3840	6650	5010	2560	2320
IN	1560	2210	16700	7260	2610	825	1030	970	875	4500
IN	2260	3090	6550	9860	21200	10700	4100	1960	1120	930
IN	1150	10900	9593	2980	2870	5100	22100	13500	11600	4030
IN	940	500	693	1539	1830	1510	3190	5449	9660	4600
IN	2510	1750	723	1850						

1
*USERS USER DESIGNED OUTPUT

SUMMARY BY PERIOD FLOOD= 1

LOC NO=					1.	1.	1.	2.	2.	2.	3.	3.	4.	4.
CODE=					1.090	1.110	1.100	2.090	2.110	2.100	3.110	3.100	4.240	4.343
					BRASSUA INFLOW	BRASSUA EOP STOR	BRASSUA OUTFLOW	MOOSEHEAD INFLOW	MOOSEHEAD EOP STOR	MOOSEHEAD OUTFLOW	FLAGGSTAF EOP STOR	FLAGGSTAF OUTFLOW	BINGHAM 6 LOCAL IN	BINGHAM 6 FLOW REG
PER	DY	MO	YR	DW										
1	1	6	51	1	551.20	185000.00	744.46	1189.66	435000.00	3021.44	220000.00	1343.90	720.80	5086.14
2	1	7	51	1	748.80	185000.11	748.80	1353.60	386219.04	2146.93	199513.72	873.87	979.20	4000.00
3	1	8	51	1	346.06	137512.72	1118.36	1397.87	307359.38	2680.38	162147.98	867.08	452.54	4000.00
4	1	9	51	1	574.08	94482.64	1297.21	1760.89	266057.34	2454.99	139847.14	794.29	750.72	4000.00
5	1	10	51	1	384.32	66514.52	838.87	1149.04	181868.55	2518.22	96868.55	979.60	502.18	4000.00
6	1	11	51	1	2040.74	95080.00	1562.03	3210.32	255000.00	1981.33	130000.00	934.53	2668.66	5584.51
7	1	12	51	1	1157.52	80001.16	1401.45	2336.37	225000.00	2824.27	115000.00	1089.83	1513.68	5427.77
8	1	1	52	1	615.16	60001.73	940.41	1437.27	172343.60	2293.64	87183.62	901.92	804.44	4000.00
9	1	2	52	1	549.64	43086.48	843.71	1287.65	109746.50	2375.89	58210.42	905.35	718.76	4000.00
10	1	3	52	1	301.60	52900.05	142.00	385.60	35000.00	1601.22	18000.00	874.35	394.40	2869.97
11	1	4	52	1	3641.30	150565.60	2000.00	4941.05	204577.30	2091.25	108084.66	1147.05	4761.70	8000.00
12	1	5	52	1	2883.66	196500.00	2136.62	4465.73	345000.00	2182.01	175000.00	1019.03	3770.94	6971.98
13	1	6	52	1	1591.98	187543.17	1742.50	3028.33	435000.00	1515.85	220000.00	407.13	2081.82	4004.81
14	1	7	52	1	39.52	181241.83	142.00	173.92	345000.00	1637.61	175000.00	760.72	51.68	2450.01
15	1	8	52	1	29.64	121388.77	1003.04	1026.98	285000.00	2002.77	145000.00	509.56	38.76	2551.09
16	1	9	52	1	58.76	82749.08	708.11	755.57	225000.00	1763.89	115000.00	547.10	76.84	2387.93
17	1	10	52	1	226.20	46137.67	821.62	1004.32	170000.00	1898.80	85000.00	653.20	295.80	2847.79
18	1	11	52	1	268.84	34143.99	470.40	687.54	135000.00	1275.72	70000.00	448.54	351.56	2075.92
19	1	12	52	1	777.92	14924.62	1090.49	1718.81	110000.00	2125.39	55000.00	812.43	1017.28	3955.10
20	1	1	53	1	651.04	6991.10	780.06	1305.90	75000.00	1875.12	38000.00	752.23	851.36	3478.71
21	1	2	53	1	634.92	0.00	760.80	1273.62	75000.00	1273.62	38000.00	463.98	830.28	2567.88
22	1	3	53	1	2771.60	47444.53	2000.00	4238.69	147817.87	3054.35	81295.25	1321.22	3624.40	7959.96
23	1	4	53	1	5210.40	196500.00	2705.48	6913.88	449362.66	1846.32	228133.24	1340.01	6813.60	9999.93
24	1	5	53	1	2363.92	196500.00	2363.92	4273.24	494013.35	3547.08	250629.89	1361.61	3091.28	7999.97
25	1	6	53	1	514.28	194250.23	552.09	967.47	416444.07	2271.04	210129.83	1056.44	672.52	4000.00
26	1	7	53	1	326.04	182578.16	515.87	779.21	345000.00	1941.11	175000.00	809.58	426.36	3177.36
27	1	8	53	1	166.66	121867.83	1154.00	1288.61	285000.00	2264.41	145000.00	609.69	217.94	3092.03
28	1	9	53	1	180.70	82864.72	836.16	982.11	225000.00	1990.43	115000.00	636.21	236.30	2862.34
29	1	10	53	1	502.06	46185.52	1098.58	1504.09	170000.00	2398.57	85000.00	854.79	656.54	3909.39
30	1	11	53	1	1336.14	35572.46	1514.50	2593.69	220310.81	1748.20	113078.44	504.54	1747.26	4000.00
31	1	12	53	1	1670.24	80000.00	947.71	2296.75	225000.00	2220.48	115000.00	1189.31	2184.16	5593.95
32	1	1	54	1	468.26	60001.35	793.50	1171.71	148603.37	2414.17	76182.05	973.49	612.34	4000.00
33	1	2	54	1	546.52	37151.33	957.95	1399.37	92984.20	2400.83	49240.13	884.49	714.68	4000.00
34	1	3	54	1	879.32	63720.08	447.23	1157.45	50470.24	1848.86	27185.45	1001.26	1149.88	4000.00
35	1	4	54	1	4438.20	196500.00	2206.79	5791.49	285000.00	1850.15	145000.00	1263.39	5803.80	8917.34
36	1	5	54	1	3515.20	196500.00	3515.20	6354.40	510448.17	2687.89	258971.18	715.26	4596.80	7999.95
37	1	6	54	1	2219.36	196500.00	2219.36	4011.92	544000.00	3448.07	276000.00	1335.67	2902.24	7685.98
38	1	7	54	1	997.88	196498.04	997.91	1803.89	456182.09	3232.09	230882.54	1462.97	1304.92	5999.99
39	1	8	54	1	1271.14	166255.40	1762.98	2789.67	439666.99	3204.63	218327.58	1133.09	1662.26	5999.98
40	1	9	54	1	2540.20	196500.00	2031.93	4083.63	544000.00	2179.03	276000.00	887.10	3321.80	6387.93
41	1	10	54	1	2495.48	196500.00	2495.48	4511.06	544000.00	4511.06	276000.00	1623.62	3263.32	9598.00
42	1	11	54	1	1806.22	196498.04	1806.25	3265.12	544000.00	3265.12	276000.00	1319.93	2361.98	6947.33
43	1	12	54	1	1233.78	196500.00	1233.67	2230.12	492714.74	3064.18	250116.22	1322.50	1613.30	5999.98
44	1	1	55	1	596.70	180426.88	858.10	1340.05	352874.70	3614.30	178214.96	1605.39	780.30	5999.99
45	1	2	55	1	630.76	133328.59	1478.80	1988.26	181656.91	5071.15	203814.65	0.00	824.84	5895.99
46	1	3	55	1	614.90	162406.50	142.00	638.65	135000.00	1397.44	75000.00	2544.29	804.10	4745.33
47	1	4	55	1	4256.20	196500.00	3683.25	7120.95	367984.04	3205.58	186572.62	1228.57	5565.80	9999.94
48	1	5	55	1	3309.80	196500.00	3309.80	5983.10	544000.00	3120.52	276000.00	970.83	4328.20	8419.55
49	1	6	55	1	1039.74	196498.04	1039.77	1879.56	465343.80	3201.40	235589.47	1438.92	1359.66	5999.99
50	1	7	55	1	1626.04	188993.32	1748.09	3061.43	480619.72	2813.00	243437.65	1060.62	2126.36	5999.98
51	1	8	55	1	444.60	172087.06	719.55	1078.65	375000.00	2796.36	190000.00	1193.97	581.40	4571.73
52	1	9	55	1	46.80	130804.63	740.56	778.36	246984.95	2929.70	131588.37	1009.10	61.20	4000.00

1

LOC NO=					1.	1.	1.	2.	2.	2.	3.	3.	4.	4.
PER	DY	MO	YR	DW	BRASSUA INFLOW	BRASSUA EOP STOR	BRASSUA OUTFLOW	MOOSEHEAD INFLOW	MOOSEHEAD EOP STOR	MOOSEHEAD OUTFLOW	FLAGGSTAF EOP STOR	FLAGGSTAF OUTFLOW	BINGHAM G LOCAL IN	BINGHAM G FLOW REG
53	1	10	55	1	50.96	72698.34	995.95	1037.11	170000.00	2289.14	85000.00	801.42	66.64	3157.20
54	1	11	55	1	679.64	48371.75	1088.46	1637.40	135000.00	2225.58	70000.00	748.74	888.76	3863.08
55	1	12	55	1	234.78	0.00	1021.46	1211.09	110000.00	1617.67	55000.00	415.52	307.02	2340.21
56	1	1	56	1	1923.10	6160.07	922.92	1749.27	101854.58	1881.74	52588.60	780.36	1337.90	4000.00
57	1	2	56	1	411.06	0.00	518.15	850.16	75000.00	1317.02	38000.00	560.96	537.54	2415.53
58	1	3	56	1	332.54	0.00	332.54	601.13	35000.00	1251.66	18000.00	568.27	434.86	2254.79
59	1	4	56	1	2227.68	15000.00	1975.60	3774.88	110000.00	2514.48	55000.00	1006.12	2913.12	6433.73
60	1	5	56	1	4464.20	166519.96	2000.00	5605.70	345000.00	1783.85	232233.17	378.29	5837.80	7999.94
61	1	6	56	1	1359.02	196500.00	855.20	1952.87	412391.54	820.33	207974.23	1402.49	1777.18	4000.00
62	1	7	56	1	498.62	182108.95	724.66	1120.93	345000.00	2216.94	175000.00	894.80	641.58	3753.31
63	1	8	56	1	262.60	121699.62	1245.05	1457.15	285000.00	2432.94	145000.00	679.80	343.40	3456.14
64	1	9	56	1	469.56	82824.12	1122.87	1502.13	225000.00	2510.45	115000.00	847.30	614.04	3971.79
65	1	10	56	1	525.20	46168.72	1121.33	1545.53	170000.00	2440.01	85000.00	871.70	686.80	3998.51
66	1	11	56	1	491.66	35564.35	669.87	1066.98	135000.00	1655.17	70000.00	611.37	642.94	2909.48
67	1	12	56	1	436.80	14678.67	776.47	1129.27	110000.00	1535.85	55000.00	563.15	571.20	2670.20
68	1	1	57	1	352.82	0.00	591.54	876.51	75000.00	1445.72	38000.00	534.30	461.38	2441.41
69	1	2	57	1	225.68	4647.42	142.00	324.28	30188.21	1131.15	15295.36	573.73	295.12	2000.00
70	1	3	57	1	479.96	7000.00	441.70	829.36	22229.46	958.79	11432.29	413.57	627.64	2000.00
71	1	4	57	1	2154.36	16185.19	2000.00	3740.06	110000.00	2265.05	55000.00	842.17	2817.24	5924.46
72	1	5	57	1	1676.74	60415.10	957.42	2311.71	200000.00	848.02	100000.00	453.47	2192.66	3534.15
73	1	6	57	1	621.14	88926.32	142.00	643.69	195282.15	722.98	99254.07	464.76	812.26	2000.00
74	1	7	57	1	408.46	100733.52	216.44	546.35	170145.02	955.16	86305.44	510.70	534.14	2000.00
75	1	8	57	1	423.80	61437.47	1062.88	1405.18	180939.05	1229.63	92056.71	216.17	554.20	2000.00
76	1	9	57	1	162.76	40717.63	510.96	642.42	140264.82	1325.97	71690.91	461.19	212.84	2000.00
77	1	10	57	1	149.76	0.00	811.96	932.92	110075.82	1423.89	55037.91	380.27	195.84	2000.00
78	1	11	57	1	1317.94	17919.67	1016.79	2081.28	138676.44	1600.64	72128.47	675.90	1723.46	4000.00
79	1	12	57	1	2460.64	80000.00	1451.01	3438.45	239436.56	1799.77	122286.16	982.44	3217.76	5999.97
80	1	1	58	1	1170.52	64526.26	1422.17	2367.59	200000.00	3008.96	100000.00	1217.82	1530.68	5757.46
81	1	2	58	1	514.28	51381.48	750.96	1166.34	131896.92	2392.58	68550.02	934.90	672.52	4000.00
82	1	3	58	1	556.14	76846.33	142.00	591.19	39989.49	2085.90	20562.51	1186.84	727.26	4000.00
83	1	4	58	1	5337.80	196500.00	3326.98	7638.28	376573.19	1981.89	191316.94	1037.84	6980.20	9999.93
84	1	5	58	1	4563.00	196500.00	4563.00	8248.50	544000.00	5525.60	276000.00	1957.28	5967.00	13449.89
85	1	6	58	1	656.50	196458.84	656.53	1186.78	435000.00	3018.56	220000.00	1420.85	858.50	5297.91
86	1	7	58	1	727.48	186097.44	896.63	1484.21	390014.76	2215.81	201476.66	832.87	951.32	4000.00
87	1	8	58	1	574.86	139266.83	1336.48	1800.79	349017.70	2467.53	179301.41	780.73	751.74	4000.00
88	1	9	58	1	332.80	110045.59	823.87	1052.67	258819.78	2608.48	136866.97	956.32	435.20	4000.00
89	1	10	58	1	867.88	80026.87	1356.08	2057.06	255000.00	2119.18	130000.00	745.90	1134.92	4000.00
90	1	11	58	1	1145.56	95000.00	893.93	1819.19	255000.00	1819.19	130000.00	837.14	1498.04	4154.37
91	1	12	58	1	527.54	80001.16	771.47	1197.56	183183.42	2365.53	95621.58	544.61	689.86	4000.00
92	1	1	59	1	537.94	47586.24	1065.11	1499.60	126531.85	2420.94	65553.78	875.60	703.46	4000.00
93	1	2	59	1	341.90	16898.32	894.46	1170.61	75000.00	2098.47	38000.00	753.18	447.10	3258.75
94	1	3	59	1	345.28	0.00	620.10	898.98	35000.00	1549.51	18000.00	577.58	451.52	2578.61
95	1	4	59	1	3668.60	99290.04	2000.00	4963.10	207746.25	2060.05	109539.26	1142.55	4797.40	8000.00
96	1	5	59	1	1940.12	109448.58	1774.91	3341.93	345000.00	1109.74	175000.00	353.18	2537.08	4000.00
97	1	6	59	1	2610.40	196500.00	1147.47	3255.87	447122.66	1539.67	226228.15	1046.69	3413.60	5999.97
98	1	7	59	1	627.38	187254.56	777.74	1284.47	385426.59	2287.85	199587.42	891.73	820.42	4000.00
99	1	8	59	1	362.18	138036.83	1162.62	1455.15	310492.94	2673.81	163438.27	852.57	473.62	4000.00
100	1	9	59	1	76.70	95793.88	786.61	848.56	225000.00	2285.29	115000.00	870.07	160.30	3255.66
101	1	10	59	1	881.92	51535.52	1601.70	2314.02	227993.63	2265.34	118879.73	581.38	1153.28	4000.00
102	1	11	59	1	2033.46	95000.00	1303.03	2945.44	272784.58	2192.71	138584.56	1148.12	2659.14	5999.97
103	1	12	59	1	1453.66	85306.91	1611.30	2785.41	262425.69	2953.88	133888.83	1145.16	1900.94	5999.98
104	1	1	60	1	623.74	73395.17	817.46	1321.25	200000.00	2336.49	100000.00	1006.95	815.66	4159.11

1

LOC NI					1.	1.	1.	2.	2.	2.	3.	3.	4.	.
PER	DY	MO	YR	DW	BRASSUA INFLOW	BRASSUA EOP STOR	BRASSUA OUTFLOW	MOOSEHEAD INFLOW	MOOSEHEAD EOP STOR	MOOSEHEAD OUTFLOW	FLAGGSTAF ECP STOR	FLAGGSTAF OUTFLOW	BINGHAM & LOCAL IN	BINGHAM & FLOW REG
105	1	2	60	1	713.18	54085.53	1048.87	1624.90	162983.04	2268.44	84622.08	798.94	932.62	4000.00
106	1	3	60	1	397.40	41916.47	585.31	898.21	67537.60	2450.46	37300.43	1042.94	506.60	4000.00
107	1	4	60	1	4498.00	190559.96	2000.00	5633.00	285000.00	1978.48	145000.00	1477.08	5882.00	9337.55
108	1	5	60	1	3614.00	196500.00	3517.40	6436.40	522007.20	2581.90	264837.82	692.05	4726.00	7999.95
109	1	6	60	1	1023.88	195510.22	1040.51	1867.49	441696.09	2217.15	223440.19	1443.92	1338.92	5999.99
110	1	7	60	1	438.36	186642.21	582.58	936.64	351611.23	2401.71	180108.68	1025.05	573.24	4000.00
111	1	8	60	1	210.08	125654.82	1201.28	1370.96	285000.00	2454.27	145000.00	724.50	274.72	3453.49
112	1	9	60	1	438.62	83708.47	1142.87	1497.14	225000.00	2505.46	115000.00	824.69	573.58	3903.73
113	1	10	60	1	503.62	46567.76	1108.95	1515.72	170000.00	2410.19	85000.00	855.93	658.58	3924.70
114	1	11	60	1	914.68	35756.99	1096.36	1835.14	155348.60	2081.36	81780.77	722.52	1196.12	4000.00
115	1	12	60	1	620.62	22711.85	832.78	1334.09	110000.00	2071.56	55000.00	889.07	811.58	3772.21
116	1	1	61	1	377.52	0.00	746.89	1051.81	75000.00	1621.02	38000.00	552.35	493.68	2667.05
117	1	2	61	1	335.40	0.00	335.40	606.30	48828.33	1077.54	24739.69	483.86	438.60	2000.00
118	1	3	61	1	607.10	0.00	607.10	1097.45	35000.00	1322.34	18000.00	553.26	793.90	2669.50
119	1	4	61	1	2388.88	23140.30	2000.00	3929.48	110000.00	2669.08	55000.00	1123.92	3123.92	6916.93
120	1	5	61	1	6094.40	196500.00	3275.82	8197.42	544000.00	1139.19	276000.00	859.43	7969.60	9968.22
121	1	6	61	1	1601.60	196498.04	1601.63	2895.23	544000.00	2895.23	276000.00	1170.40	2894.40	6160.33
122	1	7	61	1	646.10	196500.00	646.07	1167.92	435000.00	2940.61	220000.00	1382.89	844.90	5168.40
123	1	8	61	1	269.62	158961.00	880.12	1097.89	336288.58	2703.26	174060.00	944.16	352.58	4000.00
124	1	9	61	1	457.86	112542.49	1237.94	1607.75	278545.90	2578.13	144589.49	823.13	598.74	4000.00
125	1	10	61	1	316.16	77465.84	886.62	1141.98	186214.03	2643.59	101214.03	942.97	413.44	4000.00
126	1	11	61	1	605.28	57540.55	940.13	1429.01	136811.96	2259.23	71049.03	949.25	791.52	4000.00
127	1	12	61	1	752.18	23858.22	1299.31	1906.84	115061.33	2260.58	58374.22	755.80	983.62	4000.00
128	1	1	62	1	569.66	8524.56	819.68	1279.79	75000.00	1931.32	38000.00	747.64	744.94	3423.90
129	1	2	62	1	339.82	0.00	493.31	767.78	55112.87	1125.86	27523.86	429.76	444.38	2060.30
130	1	3	62	1	440.70	7000.00	326.86	682.81	35000.00	1009.91	18000.00	483.44	576.30	2069.55
131	1	4	62	1	3900.00	120059.50	2000.00	5150.00	234606.80	1795.55	121868.70	1104.45	5100.00	8000.00
132	1	5	62	1	3016.00	182531.82	2000.00	4436.00	345000.00	2640.65	175000.00	1339.91	3944.00	7924.57
133	1	6	62	1	558.48	196500.00	323.74	774.82	285000.00	1783.14	145000.00	912.28	730.32	3425.74
134	1	7	62	1	301.60	148952.24	1074.88	1318.48	282566.55	1358.05	143330.86	247.55	394.40	2000.00
135	1	8	62	1	816.14	97871.34	1646.88	2306.07	285000.00	2266.49	145000.00	569.26	1067.26	3903.02
136	1	9	62	1	312.26	77544.36	653.86	906.07	225000.00	1914.39	115000.00	732.35	408.34	3055.38
137	1	10	62	1	814.84	44638.14	1350.00	2008.14	208715.50	2272.98	110541.68	661.46	1065.56	4000.00
138	1	11	62	1	2299.18	95000.00	1452.83	3309.86	290523.63	1935.05	147546.19	1058.30	3006.62	5999.97
139	1	12	62	1	1127.36	90599.12	1198.93	2109.49	225368.67	3169.12	115186.07	1356.62	1474.24	5999.99
140	1	1	63	1	409.50	63439.03	851.21	1181.96	144380.24	2499.09	74224.99	965.41	535.50	4000.00
141	1	2	63	1	474.24	36954.97	951.10	1334.14	81916.06	2458.85	42222.54	920.99	620.16	4000.00
142	1	3	63	1	377.78	0.00	978.79	1283.92	35000.00	2046.92	18000.00	671.63	494.02	3212.57
143	1	4	63	1	3356.60	80724.48	2000.00	4711.10	171529.77	2416.67	92915.30	1193.93	4389.40	8000.00
144	1	5	63	1	4113.20	196500.00	2230.32	5552.52	417643.58	1549.92	211869.35	1071.23	5378.80	7999.95
145	1	6	63	1	440.96	190812.84	536.53	892.69	332081.87	2330.59	166018.69	1092.77	576.64	4000.00
146	1	7	63	1	548.60	159726.21	1054.17	1497.27	345000.00	1287.18	175000.00	254.84	717.40	2259.41
147	1	8	63	1	546.00	114761.57	1277.27	1718.27	295230.84	2527.68	152505.65	758.32	714.00	4000.00
148	1	9	63	1	521.30	83618.93	1044.66	1465.71	236601.70	2450.99	123564.95	867.31	681.70	4000.00
149	1	10	63	1	456.04	51298.31	981.68	1350.02	170000.00	2433.17	85000.00	966.95	556.36	3996.49
150	1	11	63	1	4108.90	176734.85	2000.00	5318.00	471571.34	250.00	241144.32	377.95	5372.00	5999.95
151	1	12	63	1	1496.30	168996.48	1622.15	2830.70	467832.47	2891.51	237558.08	1151.77	1956.70	5999.98
152	1	1	64	1	520.78	164007.45	601.92	1022.55	308896.15	3607.36	155714.31	1711.61	681.02	5999.99
153	1	2	64	1	273.00	114913.80	1126.48	1346.98	165000.00	3848.59	85000.00	1428.85	357.00	5634.44
154	1	3	64	1	505.18	137245.20	142.00	550.03	65234.83	2172.53	35551.93	1166.85	660.62	4000.00
155	1	4	64	1	2730.00	180683.85	2000.00	4205.00	135288.07	3027.73	71222.54	1402.27	3570.00	8000.00
156	1	5	64	1	1495.52	145664.13	2000.00	3207.92	230370.62	1661.57	114887.56	382.75	1955.68	4000.00

1

LOC NO=					1.	1.	1.	2.	2.	2.	3.	3.	4.	
PER	DY	MO	YR	DW	BRASSUA INFLOW	BRASSUA EOP STOR	BRASSUA OUTFLOW	MOOSEHEAD INFLOW	EHEAD EOP STOR	MOOSEHEAD OUTFLOW	FLAGGSTAF EOP STOR	FLAGGSTAF OUTFLOW	BINGHAM 6 LOCAL IN	BI 4 5 FLOW REQ
157	1	6	64	1	425.10	147615.38	459.53	802.88	215796.44	1047.80	109791.17	396.30	555.90	2000.30
158	1	7	64	1	687.96	128805.59	993.87	1549.53	254848.16	914.42	129270.81	185.94	899.64	2000.00
159	1	8	64	1	239.98	87015.35	919.62	1113.45	238396.59	1381.01	121289.50	305.17	313.82	2000.30
160	1	9	64	1	143.52	65907.02	498.25	614.17	194976.52	1343.86	99654.67	468.46	187.68	2000.30
161	1	10	64	1	263.12	38451.46	708.98	921.50	170000.00	1327.70	85000.00	430.61	344.08	2102.39
162	1	11	64	1	566.54	33940.82	643.01	1100.60	135000.00	1688.79	70000.00	666.09	740.86	3095.74
163	1	12	64	1	761.28	14906.69	1070.84	1685.72	110000.00	2092.30	55000.00	800.27	995.52	3888.18
164	1	1	65	1	514.80	0.00	757.23	1173.03	75000.00	1742.24	38000.00	652.67	673.20	3068.12
165	1	2	65	1	392.08	0.00	392.08	708.76	56864.14	1035.31	28811.16	451.97	512.72	2000.00
166	1	3	65	1	418.86	7000.00	305.02	643.33	35000.00	998.91	18000.00	481.91	547.74	2028.56
167	1	4	65	1	1594.06	15000.00	1459.62	2747.13	110000.00	1486.73	55000.00	543.09	2084.54	4114.36
168	1	5	65	1	1903.72	60000.28	1171.87	2709.49	216282.77	980.99	107581.75	529.53	2489.48	4000.30
169	1	6	65	1	646.36	90012.22	142.00	664.06	214195.40	699.14	108576.61	455.62	845.24	2000.00
170	1	7	65	1	223.08	94997.71	142.00	322.18	164516.34	1130.12	83450.32	578.16	291.72	2000.30
171	1	8	65	1	343.46	58859.96	931.18	1208.59	160629.79	1271.79	81723.93	279.07	449.14	2000.30
172	1	9	65	1	364.26	44454.42	606.35	900.56	146326.60	1140.93	74789.15	382.73	476.34	2000.00
173	1	10	65	1	1914.08	28148.47	1279.19	2098.19	170000.00	1713.18	85000.00	574.94	1326.00	3614.12
174	1	11	65	1	1062.10	32257.08	993.05	1850.90	167267.90	1896.82	88681.42	714.28	1388.90	4000.00
175	1	12	65	1	508.30	25788.16	613.51	1024.06	110000.00	1955.41	55000.00	919.22	664.70	3539.33
176	1	1	66	1	453.18	0.00	872.58	1238.61	75000.00	1807.82	38000.00	607.64	592.62	3008.38
177	1	2	66	1	187.72	2539.20	142.00	293.62	26205.69	1172.20	13277.55	582.32	245.48	2000.30
178	1	3	66	1	1382.16	2453.90	1383.55	2499.91	77576.82	1664.45	42510.58	528.11	1807.44	4000.30
179	1	4	66	1	2782.80	48986.81	2000.00	4247.00	152410.96	2989.39	82207.03	1372.61	3638.00	8000.00
180	1	5	66	1	2943.20	140000.00	1463.03	3840.23	345000.00	708.12	175000.00	641.69	3848.80	5198.51
181	1	6	66	1	947.44	187927.71	142.00	907.24	299441.44	1672.87	151447.07	1088.17	1238.96	4000.30
182	1	7	66	1	374.92	150479.83	983.94	1286.76	301228.66	1257.70	152797.15	252.02	490.28	2000.30
183	1	8	66	1	172.64	102450.45	953.75	1093.19	278310.16	1465.92	141596.40	308.32	225.76	2000.00
184	1	9	66	1	130.78	77116.87	556.52	662.15	225000.00	1558.04	115000.00	542.53	171.02	2271.59
185	1	10	66	1	537.94	44575.07	1067.17	1501.66	170000.00	2396.14	85000.00	881.01	703.46	3980.61
186	1	11	66	1	1612.78	45664.46	1594.47	2897.10	255000.00	1468.65	130000.00	422.33	2109.02	4000.30
187	1	12	66	1	836.94	62270.27	566.88	1242.87	211587.31	1948.90	108784.36	956.64	1094.46	4000.30
188	1	1	67	1	465.14	50754.78	652.42	1028.11	128889.66	2373.04	67046.43	1018.70	608.26	4000.30
189	1	2	67	1	272.48	10413.47	998.85	1218.93	75000.00	2189.25	38000.00	722.12	356.32	3267.59
190	1	3	67	1	233.74	7000.00	289.25	478.04	32170.04	1174.60	16544.59	519.74	305.66	2000.30
191	1	4	67	1	1896.18	15000.00	1761.74	3293.27	110000.00	1985.31	55000.00	739.41	2479.62	5204.35
192	1	5	67	1	3601.08	140000.00	1568.10	4476.60	345000.00	654.75	175600.00	679.92	4709.00	6043.56
193	1	6	67	1	1999.04	196500.00	949.54	2483.38	435000.00	970.90	220000.00	631.52	2483.36	4085.78
194	1	7	67	1	887.12	186097.63	1056.30	1772.82	416758.39	2069.48	212488.75	770.44	1160.08	4000.30
195	1	8	67	1	591.24	148854.23	1196.94	1674.48	371714.31	2407.04	188647.07	819.80	773.16	4000.00
196	1	9	67	1	715.52	125000.00	1116.40	1694.32	315000.00	2647.42	160000.00	1004.30	935.68	4587.40
197	1	10	67	1	956.02	95001.01	1443.90	2216.07	255000.00	3191.86	130000.00	1186.53	1250.18	5628.57
198	1	11	67	1	730.68	95001.28	730.60	1320.70	207182.04	2124.29	107006.75	920.31	955.40	4000.30
199	1	12	67	1	767.00	62816.11	1290.43	1909.93	185237.54	2266.82	96573.49	736.18	1003.00	4000.30
200	1	1	68	1	522.08	43094.24	842.82	1264.50	117388.89	2367.94	61658.92	949.34	682.72	4000.30
201	1	2	68	1	478.66	22155.97	842.67	1229.28	75000.00	1966.20	38000.00	761.10	625.94	3353.24
202	1	3	68	1	993.98	10277.05	1187.17	1990.00	73412.18	2315.82	40583.28	684.36	1299.82	4000.00
203	1	4	68	1	1235.40	143294.52	2000.00	5420.90	285000.00	1865.10	145000.00	1340.34	5538.60	8744.35
204	1	5	68	1	1361.36	145445.26	1326.38	2425.94	334457.02	1621.61	169392.03	598.15	1780.24	4000.30
205	1	6	68	1	1145.46	179167.97	582.74	1511.15	330061.29	1585.02	165116.65	911.84	1503.14	4060.30
206	1	7	68	1	509.86	156169.45	883.89	1295.70	342199.14	1098.30	173579.27	234.96	666.74	2000.30
207	1	8	68	1	16.38	113226.97	714.76	727.99	285000.00	1658.23	145000.00	476.76	21.42	2156.41
208	1	9	68	1	125.58	80778.99	670.88	772.31	225000.00	1780.63	115000.00	595.93	164.22	2540.78

LOC NO=					1.	1.	1.	2.	2.	2.	3.	3.	4.	.
PER	DY	MO	YR	DW	BRASSUA INFLOW	BRASSUA EOP STOR	BRASSUA OUTFLOW	MOOSEHEAD INFLOW	MOOSEHEAD EOP STOR	MOOSEHEAD OUTFLOW	FLAGGSTAF EOP STOR	FLAGGSTAF OUTFLOW	BINGHAM & LOCAL IA	BINGHAM & FLOW REG
209	1	10	68	1	89.44	45322.46	666.08	738.32	170000.00	1632.79	85600.00	553.26	116.96	2303.01
210	1	11	68	1	368.94	35155.81	539.79	837.78	135000.00	1425.97	70000.00	521.69	482.46	2430.12
211	1	12	68	1	509.08	15057.12	835.95	1247.13	110000.00	1653.71	55000.00	615.97	665.72	2935.40
212	1	1	69	1	407.16	0.00	652.04	980.90	75000.00	1550.11	38000.00	574.01	532.44	2656.56
213	1	2	69	1	393.12	0.00	393.12	710.64	57011.59	1034.53	28885.87	451.39	514.08	2000.30
214	1	3	69	1	329.94	7000.00	216.10	482.59	22419.39	1045.17	11529.97	523.37	431.46	2000.00
215	1	4	69	1	3411.20	90973.46	2000.00	4755.20	164810.47	2362.27	89831.04	1176.93	4460.80	8000.30
216	1	5	69	1	7763.60	196500.00	6047.40	12318.00	544000.00	6151.16	276000.00	2645.70	10152.40	18949.26
217	1	6	69	1	1702.48	196458.04	1702.51	3077.59	544000.00	3077.59	276000.00	1244.12	2226.32	6548.33
218	1	7	69	1	730.08	196500.00	730.05	1319.73	435000.00	3092.42	220000.00	1444.26	954.72	5491.40
219	1	8	69	1	780.52	158961.00	1391.02	2021.44	375000.00	2997.24	190000.00	1058.28	1020.68	5076.19
220	1	9	69	1	1225.38	126346.14	1773.48	2763.21	345555.16	3258.04	175477.72	1139.52	1602.42	5999.98
221	1	10	69	1	261.30	105776.33	595.83	806.88	235481.61	2597.03	121963.02	1061.27	341.70	4000.00
322	1	11	69	1	3289.08	182478.27	2000.00	4656.50	448632.32	1074.44	227821.17	624.52	4301.00	5999.36
223	1	12	69	1	2385.76	196500.00	2157.72	4084.68	544000.00	2533.70	276000.00	959.90	3119.84	6613.44
224	1	1	70	1	1037.14	196498.04	1037.17	1874.86	462200.39	3205.19	234149.04	1438.54	1356.26	5999.99
225	1	2	70	1	1526.46	171560.92	1975.47	3208.38	442173.34	3568.98	276000.00	361.93	1996.14	5927.06
226	1	3	70	1	583.44	196500.00	177.85	649.09	221699.23	4234.71	117607.69	3002.33	762.96	7999.99
227	1	4	70	1	3749.20	196500.00	3749.20	6777.48	399439.44	3790.42	202882.50	1306.73	4902.80	9999.35
228	1	5	70	1	4230.20	196500.00	4230.20	7646.90	544000.00	5295.88	276000.00	1902.18	5531.80	12729.86
229	1	6	70	1	743.34	196498.04	743.37	1343.76	435000.00	3175.54	220000.00	1484.31	972.06	5631.91
230	1	7	70	1	321.10	186097.44	490.25	749.60	345000.00	2213.29	175000.00	966.49	419.90	3599.68
231	1	8	70	1	44.72	123129.46	1068.78	1104.90	285000.00	2080.69	145000.00	520.58	58.48	2659.75
232	1	9	70	1	187.72	83169.25	859.26	1010.88	225000.00	2019.20	115006.00	641.34	245.48	2906.32
233	1	10	70	1	1262.82	90864.79	1137.67	2157.64	255000.00	1669.74	130000.00	678.88	1651.38	4000.30
234	1	11	70	1	754.52	93205.71	715.18	1324.60	209359.77	2091.60	107562.83	521.72	986.68	4000.00
235	1	12	70	1	626.08	62953.45	1118.08	1623.76	163284.86	2373.08	86400.30	808.20	818.72	4000.30
236	1	1	71	1	324.22	36617.81	752.52	1014.39	75000.00	2450.19	38000.00	1024.07	423.98	3898.24
237	1	2	71	1	511.94	0.00	1171.27	1584.76	75000.00	1584.76	38000.00	374.11	669.46	2628.33
238	1	3	71	1	463.32	0.00	463.32	837.54	35000.00	1488.07	18000.00	663.84	605.88	2757.79
239	1	4	71	1	2888.60	52876.14	2000.00	4333.10	122296.25	2866.06	62888.16	1356.54	3777.40	8000.00
240	1	5	71	1	5249.40	196500.00	2913.62	7153.52	524836.03	606.93	266273.56	528.40	6864.60	7999.33
241	1	6	71	1	530.40	195637.55	544.89	973.29	435000.00	2483.02	220000.00	1165.24	693.60	4341.96
242	1	7	71	1	186.16	186015.32	342.65	493.01	345000.00	1956.70	175000.00	867.88	243.44	3068.32
243	1	8	71	1	325.00	123100.02	1348.20	1610.70	285000.00	2586.50	145000.00	725.40	425.00	3736.99
244	1	9	71	1	134.68	83162.14	805.85	914.63	225000.00	1922.95	115000.00	602.58	176.12	2701.65
245	1	10	71	1	216.32	46308.59	815.68	990.40	170000.00	1884.87	85600.00	645.98	282.88	2813.73
246	1	11	71	1	229.84	27085.06	552.90	738.54	135000.00	1326.72	70000.00	420.04	300.56	2047.32
247	1	12	71	1	316.68	0.00	757.17	1012.95	110000.00	1419.53	55000.00	475.37	414.12	2309.02
248	1	1	72	1	256.10	0.00	256.10	462.95	68090.16	1144.54	34499.01	520.56	334.90	2000.00
249	1	2	72	1	289.38	7000.00	167.69	401.42	29580.27	1070.90	14587.34	550.68	378.42	2000.30
250	1	3	72	1	485.42	7000.00	485.42	877.49	24030.89	967.74	12358.74	397.48	634.78	2000.30
251	1	4	72	1	1264.90	15000.00	1130.46	2152.11	110000.00	707.37	55000.00	207.75	1654.10	2569.22
252	1	5	72	1	7194.20	196500.00	4242.43	10053.13	544000.00	2994.90	276000.00	1663.13	9407.60	14065.83
253	1	6	72	1	1713.40	196498.04	1713.43	3097.33	544000.00	3097.33	276000.00	1252.10	2240.60	6596.03
254	1	7	72	1	1409.72	196500.00	1409.69	2548.31	508458.82	3126.32	276000.00	1030.18	1843.48	5999.38
255	1	8	72	1	396.02	184260.09	505.08	752.25	375000.00	2922.72	190000.00	1622.27	400.18	4945.16
256	1	9	72	1	75.66	134939.42	904.51	965.62	257353.45	2942.71	136263.18	958.35	98.94	4000.00
257	1	10	72	1	335.14	77857.63	1262.82	1533.51	184481.55	2718.64	99481.55	843.10	438.26	4060.90
258	1	11	72	1	767.00	56976.10	1118.59	1738.09	158689.44	2171.54	83714.94	825.46	1003.00	4000.00
259	1	12	72	1	853.84	31685.67	1265.14	1954.78	145507.17	2169.17	78161.86	714.27	1116.56	4000.30
260	1	1	73	1	756.86	22057.44	913.45	1524.76	109230.75	2114.73	57105.54	895.53	989.74	4000.00

1

LOC NO=					1.	1.	1.	2.	2.	2.	3.	3.	4.	.
PER	DY	MO	YR	DW	BRASSUA INFLOW	BRASSUA EOP STOR	BRASSUA CUTFLOW	MOOSEHEAD INFLOW	MOOSEHEAD EOP STOR	MOOSEHEAD CUTFLOW	FLAGGSTAF EOP STOR	FLAGGSTAF OUTFLOW	BINGHAM G LOCAL IN	BINGHAM G FLOW RES
261	1	2	73	1	998.40	18047.48	1070.60	1877.00	105371.13	1946.50	56089.03	747.90	1305.60	4000.00
262	1	3	73	1	1575.86	34333.54	1311.00	2583.81	135000.00	2101.95	75000.00	844.04	2060.74	5006.72
263	1	4	73	1	4898.40	196500.00	2173.14	6129.54	380538.83	2003.19	193322.73	1591.15	6405.60	9999.94
264	1	5	73	1	3582.80	196500.00	3582.80	6476.60	544000.00	3818.20	276000.00	1273.60	4685.20	9777.30
265	1	6	73	1	1478.10	196498.04	1478.13	2671.98	531619.61	2880.04	269639.43	1187.04	1932.90	5999.98
266	1	7	73	1	1513.46	195318.40	1532.64	2755.05	525128.77	2860.62	266304.69	1160.22	1979.14	5999.38
267	1	8	73	1	1019.72	189594.25	1112.81	1936.43	444180.86	3252.91	225204.46	1413.60	1333.48	5999.99
268	1	9	73	1	959.66	160249.74	1452.80	2227.91	372305.44	3435.80	189028.08	1309.25	1254.94	5999.99
269	1	10	73	1	988.78	126263.42	1541.51	2340.14	304980.67	3435.05	155249.75	1271.91	1293.02	5999.39
270	1	11	73	1	923.78	116118.23	1094.27	1840.40	255000.00	2680.34	130000.00	1099.40	1208.02	4987.76
271	1	12	73	1	3619.20	196500.00	2311.93	5235.13	525132.52	841.91	266477.54	425.24	4732.80	5999.35
272	1	1	74	1	895.96	190587.68	992.11	1715.77	425241.59	3340.32	215239.88	1488.03	1171.64	5999.39
273	1	2	74	1	475.54	158490.51	1053.47	1437.56	212166.05	5274.13	234539.90	0.00	621.86	5895.39
274	1	3	74	1	1177.28	196500.00	559.12	1510.00	135000.00	2764.97	75000.00	3454.95	1539.52	7759.44
275	1	4	74	1	4186.08	196500.00	4186.00	7567.08	379955.88	3450.44	193027.88	1075.50	5474.00	9999.35
276	1	5	74	1	5738.20	196500.00	5738.20	10372.90	544000.00	7705.02	276000.00	2843.91	7503.80	18052.72
277	1	6	74	1	1562.86	196458.04	1562.89	2825.20	544000.00	2825.20	276000.00	1142.09	2043.74	6011.33
278	1	7	74	1	1000.22	196500.00	1000.19	1808.06	456545.07	3230.36	231069.03	1461.65	1307.98	5999.39
279	1	8	74	1	406.90	166301.08	896.73	1225.38	375000.00	2551.56	190000.00	965.26	532.10	4048.93
280	1	9	74	1	282.62	128866.50	913.06	1141.33	282541.70	2695.12	146634.82	935.30	369.58	4000.00
281	1	10	74	1	166.40	84750.30	883.87	1018.27	175845.68	2753.49	90845.68	1028.91	217.60	4000.00
282	1	11	74	1	639.08	56202.26	1118.84	1635.02	135000.00	2321.44	70000.00	817.34	835.72	3974.50
283	1	12	74	1	1209.30	22747.17	1753.09	2729.59	182922.12	1950.22	95500.49	468.78	1581.00	4000.00
284	1	1	75	1	506.48	30511.39	380.21	789.29	95206.15	2215.83	49277.85	1121.85	662.32	4000.30
285	1	2	75	1	359.32	0.00	908.70	1198.92	75000.00	1562.74	38000.00	465.65	469.88	2498.27
286	1	3	75	1	901.94	6402.51	797.81	1526.30	49143.28	1963.08	25803.82	857.46	1179.46	4000.00
287	1	4	75	1	2186.86	17521.61	2000.00	3766.31	110000.00	2726.79	55000.00	1107.44	2859.74	6693.37
288	1	5	75	1	4245.88	155612.49	2000.00	5429.30	345000.00	1607.45	194111.75	840.30	5552.20	7999.94
289	1	6	75	1	1678.04	196500.00	990.91	2346.25	427982.31	951.71	216267.19	853.93	2194.36	4000.00
290	1	7	75	1	281.58	185427.89	461.65	689.08	345000.00	2038.64	175000.00	876.91	368.22	3283.76
291	1	8	75	1	69.42	122889.43	1086.50	1142.57	285000.00	2118.36	145000.00	538.63	90.78	2747.76
292	1	9	75	1	260.00	83111.31	928.48	1138.48	225000.00	2146.80	115000.00	694.16	340.80	3180.96
293	1	10	75	1	626.60	46287.56	1225.47	1731.57	182028.52	2430.43	97028.52	750.17	819.40	4000.30
294	1	11	75	1	825.50	41428.59	907.16	1573.91	153888.77	2046.80	80535.61	873.70	1079.50	4000.00
295	1	12	75	1	728.00	24250.77	1007.37	1595.37	117929.60	2180.18	60286.40	867.82	952.00	4000.00
296	1	1	76	1	520.08	2232.50	878.09	1298.09	75000.00	1996.26	38000.00	742.45	680.00	3418.71
297	1	2	76	1	889.20	6593.09	813.39	1531.59	75000.00	1531.59	38000.00	649.80	1162.80	3344.19
298	1	3	76	1	2111.20	36000.00	1730.53	3435.73	135000.00	2459.94	75000.00	941.06	2760.80	6161.90
299	1	4	76	1	4953.00	196500.00	2154.92	6155.42	385959.60	1937.96	196064.51	1584.97	6477.00	9999.34
300	1	5	76	1	2834.08	196500.00	2834.00	5123.00	504427.55	3196.33	255915.49	1097.63	3706.00	7999.36
301	1	6	76	1	569.40	194718.97	599.33	1059.23	434621.40	2232.34	219798.62	1023.06	744.60	4000.00
302	1	7	76	1	2012.40	195481.42	2000.00	3625.40	504792.48	2484.19	255856.69	884.18	2631.60	5999.97
303	1	8	76	1	1840.80	185692.46	2000.00	3486.80	544000.00	2849.16	276000.00	1017.61	2407.20	6273.37
304	1	9	76	1	465.40	196500.00	283.78	659.68	370541.97	3574.69	188134.80	1816.70	608.60	5999.99
305	1	10	76	1	1749.80	181115.58	2000.00	3413.30	410428.32	2764.62	208520.88	947.16	2288.20	5999.38
306	1	11	76	1	1068.60	157783.87	1460.70	2323.80	351211.95	3318.95	178605.34	1283.64	1397.40	5999.39
307	1	12	76	1	938.60	127435.26	1432.17	2190.27	273653.58	3451.61	139555.57	1320.97	1227.40	5999.39
308	1	1	77	1	280.80	90118.76	887.69	1114.49	180169.13	2634.84	90810.09	997.96	367.20	4000.30
309	1	2	77	1	208.00	53138.15	873.86	1041.86	85608.14	2744.50	44630.09	983.50	272.00	4000.00
310	1	3	77	1	6344.00	196500.00	4012.48	9136.48	544000.00	1681.56	276000.00	873.18	8296.00	10850.74
311	1	4	77	1	3692.00	196500.00	3692.00	6674.00	544000.00	6674.00	276000.00	2698.00	4828.00	14200.00
312	1	5	77	1	912.60	196498.04	912.63	1649.73	360866.49	4628.07	183052.84	2178.52	1193.40	7999.39

1

LOC NO=					1.	1.	1.	2.	2.	2.	3.	3.	4.	4.
PER	DY	MO	YR	DW	BRASSUA INFLOW	BRASSUA EOP STOR	BRASSUA OUTFLOW	MOOSEHEAD INFLOW	MOOSEHEAD EOP STOR	MOOSEHEAD OUTFLOW	FLAGGSTAF EOP STOR	FLAGGSTAF OUTFLOW	BINGHAM & LOCAL IN	BINGHAM 3 FLOW REG
313	1	6	77	1	1768.00	188257.23	1906.49	3334.49	425000.00	2088.65	220600.00	671.09	2312.00	5071.74
314	1	7	77	1	392.60	185310.97	440.52	757.62	345000.00	2221.30	175000.00	1018.74	513.40	3753.45
315	1	8	77	1	626.60	122847.52	1642.46	2148.56	318118.52	2585.73	166578.21	594.87	819.40	4000.00
316	1	9	77	1	1053.00	125000.00	1016.83	1867.33	315000.00	1919.73	160800.00	880.05	1377.00	4176.78
317	1	10	77	1	4264.00	196500.00	3101.18	6545.18	544000.00	2820.91	276000.00	1229.47	5576.00	9626.38
318	1	11	77	1	1791.40	196498.04	1791.43	3238.33	544000.00	3238.33	276000.00	1309.10	2342.60	6890.03
319	1	12	77	1	889.20	196500.00	889.17	1607.37	438569.45	3322.01	222788.97	1515.18	1162.80	5999.99
320	1	1	78	1	2652.00	196500.00	2652.00	4794.00	544000.00	3079.36	276000.00	1072.62	3468.00	7619.98
321	1	2	78	1	842.40	196498.04	842.44	1522.84	390717.70	4282.79	276000.00	615.60	1101.60	5999.99
322	1	3	78	1	728.00	196500.00	727.97	1315.97	226841.36	3981.12	120134.75	3066.87	952.00	7999.99
323	1	4	78	1	3900.00	196500.00	3900.00	7050.00	427452.76	3678.66	217051.39	1221.29	5100.00	9999.95
324	1	5	78	1	3536.00	196500.00	3536.00	6392.00	544000.00	4496.57	276000.00	1625.31	4624.00	10745.98
325	1	6	78	1	1040.00	196498.04	1040.03	1880.03	465383.11	3201.21	235609.67	1438.77	1360.00	5999.99
326	1	7	78	1	389.40	188997.87	431.39	681.29	353862.65	2494.97	181848.41	1100.43	404.60	4000.00
327	1	8	78	1	158.60	127346.13	1161.24	1289.34	285000.00	2409.27	145000.00	715.17	287.40	3331.94
328	1	9	78	1	106.60	84187.07	831.90	918.00	225000.00	1926.32	115000.00	582.06	139.40	2647.78
329	1	10	78	1	157.30	46732.70	766.43	893.48	170000.00	1787.95	85000.00	602.85	205.70	2596.50
330	1	11	78	1	150.80	12856.66	720.10	841.90	134591.01	1436.96	69787.93	365.84	197.20	2000.00
331	1	12	78	1	96.20	0.00	305.29	382.99	78006.23	1303.24	39003.11	570.96	125.80	2000.00
332	1	1	79	1	540.80	0.00	540.80	977.60	75000.00	1026.49	38000.00	411.51	707.20	2145.20
333	1	2	79	1	327.60	0.00	327.60	592.20	47722.49	1083.35	24179.39	488.25	428.40	2000.00
334	1	3	79	1	3120.00	68867.12	2000.00	4520.00	161143.33	2675.41	87847.94	1244.55	4080.00	7999.96
335	1	4	79	1	4524.00	196500.00	2379.09	6033.09	372461.58	2481.82	189237.33	1602.12	5916.00	9999.94
336	1	5	79	1	3068.00	196500.00	3068.00	5546.00	527653.93	3022.08	267703.75	965.88	4012.00	7999.96
337	1	6	79	1	1274.00	195764.38	1286.36	2315.36	484967.44	3032.72	245671.35	1301.26	1666.00	5999.98
338	1	7	79	1	361.40	150756.10	442.20	734.10	378419.81	2466.91	196702.27	1060.49	472.60	4000.00
339	1	8	79	1	249.60	136794.57	1127.84	1329.44	291881.24	2736.03	150217.33	936.77	326.40	4000.00
340	1	9	79	1	345.80	88676.43	1154.44	1433.74	225000.00	2557.70	115000.00	846.22	452.20	3856.12
341	1	10	79	1	878.80	48590.37	1530.73	2240.53	224515.59	2248.41	117447.60	602.39	1149.20	4000.00
342	1	11	79	1	1097.20	61631.12	878.05	1764.25	226107.46	1737.49	115506.08	827.71	1434.80	4000.00
343	1	12	79	1	676.00	57625.03	741.15	1287.15	170289.41	2194.93	89646.31	921.07	884.00	4000.00
344	1	1	80	1	286.00	37115.42	619.55	850.55	75000.00	2400.26	38000.00	1048.93	374.00	3823.20
345	1	2	80	1	130.00	7000.00	653.55	758.55	37721.13	1406.64	19112.04	423.36	170.00	2000.00
346	1	3	80	1	577.20	7000.00	577.20	1043.40	35000.00	1087.65	18000.00	439.89	754.80	2282.34
347	1	4	80	1	2990.00	65909.95	2000.00	4415.00	132758.05	2772.15	69599.50	1317.85	3910.00	8000.00
348	1	5	80	1	1287.00	85784.08	963.78	2003.28	200000.00	909.71	100000.00	446.09	1683.00	3038.90
349	1	6	80	1	356.20	98530.05	142.00	429.70	165542.50	1008.77	84223.38	525.43	465.80	2000.00
350	1	7	80	1	273.00	76809.30	626.25	846.75	141365.44	1239.95	71707.11	403.05	357.00	2000.00
351	1	8	80	1	260.00	28421.21	1046.95	1256.95	132539.67	1400.48	67432.47	259.52	340.00	2000.00
352	1	9	80	1	213.20	0.00	690.83	863.03	104676.26	1331.28	53581.20	389.92	278.80	2000.00
353	1	10	80	1	642.20	0.00	642.20	1160.90	124718.03	834.96	62359.02	325.24	839.80	2000.00
354	1	11	80	1	704.60	20303.29	363.40	932.50	135000.00	759.71	70000.00	386.49	921.40	2067.50
355	1	12	80	1	709.80	13703.38	817.14	1390.44	110000.00	1797.02	55000.00	762.65	928.20	3487.86
356	1	1	81	1	215.80	0.00	438.66	612.96	70859.63	1249.51	35902.21	468.29	282.20	2000.00
357	1	2	81	1	2207.40	50000.00	1307.12	3090.02	165000.00	1394.95	85000.00	729.06	2886.60	5010.61
358	1	3	81	1	670.80	82515.12	142.00	683.80	83789.08	2004.55	46382.13	1118.25	877.20	4000.00
359	1	4	81	1	1313.00	41635.18	2000.00	3060.50	110000.00	2620.02	55600.00	814.67	1717.00	5151.59
360	1	5	81	1	1222.00	69322.59	771.71	1758.71	200000.00	295.03	100000.00	161.16	1598.00	2054.18
361	1	6	81	1	959.40	112714.40	230.19	1005.09	236730.04	387.83	120441.60	357.57	1254.60	2000.00
362	1	7	81	1	460.20	123855.13	279.02	650.72	220195.30	919.62	111693.27	478.58	601.80	2000.00
363	1	8	81	1	520.00	78033.15	1265.21	1685.21	250343.03	1194.91	127367.51	125.09	680.00	2000.00
364	1	9	81	1	998.40	66507.37	1192.09	1998.49	247506.83	2046.16	132208.69	648.24	1305.60	4000.00

LOC NO=	1.	1.	1.	2.	2.	2.	3.	3.	4.	
PER DY MO YR DW	BRASSUA INFLOW	BRASSUA EOP STOR	BRASSUA OUTFLOW	MOOSEHEAD INFLOW	MOOSEHEAD EOP STOR	MOOSEHEAD OUTFLOW	FLAGGSTAF EOP STOR	FLAGGSTAF OUTFLOW	BINGHAM 6 LOCAL IN	BINGHAM 6 FLOW RES
365 1 10 81 1	1729.00	95000.00	1265.62	2662.12	259113.64	2473.35	132078.17	1265.62	2261.00	5999.98
366 1 11 81 1	1302.60	96070.24	1284.61	2336.71	255000.00	2405.85	130000.00	986.82	1703.40	5096.37
367 1 12 81 1	665.60	80320.46	921.74	1459.34	206007.67	2256.11	106198.68	873.49	870.40	4000.00
368 1 1 82 1	603.20	54456.98	1023.82	1511.02	155425.58	2333.65	79343.56	877.55	788.80	4000.00
369 1 2 82 1	405.60	37470.79	711.45	1039.05	76995.45	2451.24	39247.16	1018.36	538.40	4000.00
370 1 3 82 1	574.60	0.00	1184.00	1648.10	35000.00	2331.08	18000.00	765.45	751.40	3847.32
371 1 4 82 1	4342.00	139360.71	2000.00	5507.00	285000.00	1305.67	145000.00	1038.73	5678.00	8022.40
372 1 5 82 1	1887.60	196500.00	958.33	2482.93	345000.00	1507.14	175000.00	891.50	2468.40	4867.34
373 1 6 82 1	678.60	187543.17	829.12	1377.22	296231.03	2196.80	150013.85	915.80	887.40	4000.30
374 1 7 82 1	214.50	149544.16	832.49	1005.74	273342.77	1377.97	138652.13	341.53	280.50	2000.30
375 1 8 82 1	267.80	95913.60	1140.00	1356.30	269080.84	1425.62	136500.78	224.18	350.20	2000.00
376 1 9 82 1	252.20	73923.72	621.75	825.45	225000.00	1566.24	115000.00	552.35	329.80	2448.39
377 1 10 82 1	227.50	44103.95	712.47	896.22	170000.00	1790.69	85000.00	654.15	297.50	2742.34
378 1 11 82 1	1170.00	34854.48	1325.44	2270.44	193153.91	1881.33	100848.06	588.67	1530.00	4000.00
379 1 12 82 1	587.60	36159.50	566.38	1040.98	122424.18	2191.27	63282.79	1040.33	768.40	4000.30
380 1 1 83 1	803.40	16687.75	1120.07	1768.97	98248.35	2162.15	50575.82	787.25	1050.60	4000.30
381 1 2 83 1	1703.00	58900.00	1103.19	2478.69	165000.00	1276.78	85000.00	631.87	2227.00	4135.65
382 1 3 83 1	2563.60	196500.00	181.04	2251.64	140277.22	2653.71	77593.45	1993.85	3352.40	7999.37
383 1 4 83 1	5512.00	196500.00	5512.00	9964.00	544000.00	3179.31	276000.00	693.72	7208.00	11081.03
384 1 5 83 1	2782.00	196500.00	2782.00	5029.00	544000.00	5029.00	276000.00	2033.00	3638.00	10700.30
385 1 6 83 1	1066.00	196498.04	1066.03	1927.03	469314.06	3182.15	237629.24	1423.83	1394.00	5999.99
386 1 7 83 1	509.60	189372.22	625.49	1037.09	387989.73	2359.68	200642.83	973.92	666.40	4000.00
387 1 8 83 1	291.20	139714.85	1098.79	1333.99	302601.72	2722.67	158601.33	896.53	380.80	4000.00
388 1 9 83 1	241.80	93566.51	1017.34	1212.64	225000.00	2516.76	115000.00	909.43	316.20	3742.39
389 1 10 83 1	299.00	50613.85	997.55	1239.05	170000.00	2133.52	85000.00	706.40	391.00	3230.32
390 1 11 83 1	2834.00	100241.02	2000.00	4289.00	329375.67	1610.64	167573.87	683.32	3706.00	5959.96
391 1 12 83 1	2493.40	196500.00	927.92	2941.82	412037.86	1597.47	209298.42	1141.90	3260.60	5999.37
392 1 1 84 1	540.80	155140.10	1213.44	1650.24	280550.04	3788.66	141211.65	1504.14	707.20	5999.99
393 1 2 84 1	746.20	103567.76	1642.77	2245.47	165000.00	4254.29	128292.29	769.90	975.80	5999.39
394 1 3 84 1	1326.00	176370.15	142.00	1213.00	135000.00	1700.90	75000.00	1835.70	1734.00	5270.60
395 1 4 84 1	5746.00	196500.00	5407.71	10048.71	544000.00	3175.34	276000.00	821.13	7514.00	11510.47
396 1 5 84 1	3510.00	196500.00	3510.00	6345.00	544000.00	6345.00	276000.00	2565.00	4590.00	13500.30
397 1 6 84 1	3016.00	196500.00	3016.00	5452.00	544000.00	5452.00	276000.00	2204.00	3944.00	11600.00
398 1 7 84 1	1047.80	196498.04	1047.83	1894.13	463981.09	3195.50	234889.37	1434.29	1370.20	5999.39
399 1 8 84 1	244.40	168941.36	692.56	889.96	356067.90	2644.97	182204.43	1035.43	319.60	4000.00
400 1 9 84 1	130.30	123211.06	898.51	1003.51	245158.28	2867.38	130576.85	962.62	170.00	4000.30
401 1 10 84 1	179.40	69321.27	1055.82	1200.72	170000.00	2423.03	85000.00	872.33	234.60	3529.36
402 1 11 84 1	397.80	46741.44	777.26	1098.56	135000.00	1686.75	70000.00	542.78	520.20	2749.73
403 1 12 84 1	475.80	19290.33	922.24	1306.54	110000.00	1713.12	55000.00	551.65	622.20	2926.37
404 1 1 85 1	392.60	0.00	706.32	1023.42	75000.00	1592.63	38000.00	563.37	513.40	2669.41
405 1 2 85 1	829.40	2128.53	791.07	1460.97	75000.00	1460.97	38000.00	606.10	1084.60	3151.67
406 1 3 85 1	1414.40	6584.21	1341.94	2484.34	126716.67	1643.26	70371.08	507.14	1849.60	4000.00
407 1 4 85 1	2511.60	49148.82	1796.29	3824.85	163892.00	3200.15	89409.44	1515.45	3284.40	8000.30
408 1 5 85 1	1196.00	90200.91	528.36	1494.36	200000.00	907.13	100000.00	701.76	1564.00	3172.89
409 1 6 85 1	652.60	118792.90	172.10	699.20	200000.78	699.19	101754.78	447.41	853.40	2000.00
410 1 7 85 1	455.00	112991.56	549.35	916.85	193853.36	1016.83	98331.41	388.17	595.00	2000.00
411 1 8 85 1	187.20	65594.79	892.97	1044.17	173255.19	1427.95	86621.06	327.25	244.80	2000.30
412 1 9 85 1	481.00	48578.01	834.19	1222.69	177993.06	1092.66	90574.23	278.34	629.00	2060.30
SUM =	504552.88	42420241.32	506779.37	914302.85	***********	920828.85	53577303.95	371350.73	659799.92	1951979.50
MAX =	7763.60	196500.00	6047.40	12318.00	544000.00	7705.02	276000.00	3454.95	10152.40	18949.26
MIN =	16.38	0.00	142.00	173.92	22229.46	250.00	11432.29	0.00	21.42	2000.00
PMAX=	216.00	24.00	216.00	216.00	37.00	276.00	37.00	274.00	216.00	216.30
AVG =	1224.64	102961.75	1230.05	2219.18	252281.53	2235.02	130042.00	901.34	1601.46	4737.91